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Working Party on National Environmental Policy

OECD/IEA JOINT WORKSHOP ON THE DESIGN OF SUSTAINABLE BUILDING POLICIES

SUMMARY, CONCLUSIONS AND CONTRIBUTED PAPERS: PART ONE

28-29 June 2001

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FOREWORD

OECD's Sustainable Buildings Project was initiated in the spring of 1998 as a four-year project with the objective to provide guidance regarding the design of government policies to address the environmental impact of the building sector. Among various environmental issues related to this sector, the reduction of CO₂ emissions, minimisation of construction and demolition waste and prevention of indoor air pollution were selected as priorities of the project.

With the objective of obtaining insights for policy design and providing suggestions and guidance to policy makers and experts in Member countries on government policies to address the environmental impact of the building sector, the OECD and IEA jointly organised the Workshop on the Design of Sustainable Building Policies on 28-29 June 2001, in Paris. In total, 68 participants with a wide variety of backgrounds from 22 countries, including 6 participants from 6 EIT countries, attended the workshop and engaged in fruitful discussions over two days of sessions.

This document contains a summary of the discussions, conclusions and papers presented at the workshop. The OECD would like to express its appreciation to those persons who prepared presentations and papers for this workshop. The OECD would like to express special thanks to the Japanese Ministry of Land, Infrastructure and Transport as well as the Annex I Expert Group for its financial support for the Workshop. Takahiko Hasegawa of the OECD Secretariat prepared the report under the auspices of the Working Party for National Environmental Policies. It is published under the responsibility of the Secretary-General of the OECD.

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EXECUTIVE SUMMARY

The construction, use and demolition of buildings have considerable impact on the natural and built environment. In recent years, more and more experts in the building sector have become aware of the importance of sustainability, and many technical developments have improved the environmental characteristics of buildings. In light of this trend, several workshops and conferences have been organised to exchange information and discuss how to tackle the issue. However, most efforts to date have been focused on technical issues and limited time has been spent on the discussion of policy issues. While the development of new technologies is fundamental to changing building activities, this should be coupled with the analysis of policy design. The policy dimension is particularly important for buildings because the sector's nature is such that policies often need to be very different in nature from those for other sectors.

Against this background, the OECD/IEA Joint Workshop on the Design of Sustainable Building Policies was held at the IEA in Paris on 28-29 June 2001. The objective of the workshop was to obtain insights for policy design and provide suggestions and guidance to policy makers and experts in Member countries on government policies to address the environmental impact of the building sector. The workshop was also intended to facilitate the exchange of information on experiences in Member countries and to discuss key issues such as barriers to effective policy and the choice of policy instruments.

This report contains a summary of the discussions, conclusions and papers presented at the workshop. The major conclusions and findings are summarised below. Building regulations that have long played a central role in the energy efficiency improvement of buildings can have an impact on only a small proportion of *newly-built* constructions, and governments need to place more emphasis on economic instruments and information tools.

- Governments need to pay special attention to the development of policy instruments for *existing* buildings since these have great energy saving potential.
- Governments need to ensure that the standards set in their building regulations are flexible so that they do not obstruct the diffusion of new and more efficient technologies.
- The lack of information on the demand side is one of the main barriers to improving energy efficiency. Information tools, such as the environmental labelling of buildings, have great potential for increasing the energy efficiency in both new and existing buildings, as well as in commercial and residential buildings.
- An energy tax may be effective for the improvement of energy efficiency if stakeholders are convinced that the tax will be maintained in the long term.
- A capital subsidy for energy efficiency measures can bring some results. However, such a subsidy usually cannot have an impact on a large number of buildings due to fiscal constraints.
- A landfill tax and regulatory instruments, such as a ban on landfill, can effectively reduce the amount of construction and demolition waste that goes to final disposal, but these do not necessarily encourage substituting primary materials with secondary materials. Other instruments need to be coupled with these instruments.

- Lack of information is one of the main barriers to the development of a secondary materials market; it is necessary to introduce information tools such as a waste information exchange, material certificates, *etc.*
- In order to improve resource efficiency in the building industry, it is important to explore possible measures at upstream stages to encourage the building industry to close the product cycle loop and take the ecological dimension into consideration in its product design.
- Furthermore, policies at upstream stages, the demolition stage and downstream stages should be effectively co-ordinated to create synergies.
- The causal mechanism of indoor air pollution is complex, so that it is often technically difficult to control the indoor air quality with regulatory instruments only.
- Environmental labelling schemes of buildings or building materials are effective for achieving a healthier indoor air environment.
- Governments need to monitor the environmental performance of to better understand the effectiveness of policy instruments and receive guidance for future improvements.
- It is necessary for governments to understand that no single instrument can solve all these problems, and that they need to take a holistic approach by integrating various instruments to create effective policy packages.
- Governments should help develop the demand for more environmentally friendly buildings through their procurement policies.
- With close collaboration between experts on policy design and technical experts, the evaluation of policy instruments is necessary to obtain more empirical evidence on the effectiveness and efficiency of these instruments.

1. Introduction

The construction, use and demolition of buildings have considerable impact on the natural and built environment. At present, the building sector is responsible for about 30% of primary energy use in OECD countries. Material flow analyses for some Member countries show that the sector accounts for between one-third and one-half of commodity flows when expressed in terms of weight. In addition, indoor air quality has a large impact on human health because people usually spend as much as 80-90% of their time indoors.

The OECD initiated the Sustainable Building Project in 1998 with an aim to provide guidance for Member countries in the design of government policies to address the environmental impact of the building sector for. This sector has great significance also for the work of the International Energy Agency (IEA), which has been conducting the extensive studies on how to improve the energy efficiency of many products including buildings, and for the work of the Annex I Experts Group, which has been reviewing a wide range of domestic greenhouse gas mitigation policies.

In recent years, more and more experts in the building sector have become aware of the importance of sustainability, and many technical developments have improved the environmental characteristics of buildings. In light of this trend, several workshops and conferences have been organised to exchange information and discuss how to tackle the issue. However, most efforts to date have been focused on technical issues, such as the development of new appliances or new design methods, and limited time has been spent on the discussion of policy issues. While the development of new technologies is fundamental to changing building activities, this should be coupled with the analysis of policy design. The policy dimension is particularly important for buildings because the sector's nature is such that policies often need to be very different in nature from those for other sectors.

Against this background, the OECD/IEA Joint Workshop on the Design of Sustainable Building Policies was held at the IEA in Paris on 28-29 June 2001 with financial support from the Japanese government and the Annex I Expert Group. This workshop was organised as part of the following three programmes: the Sustainable Building Project of the OECD, the Energy Efficiency Programme of the IEA, and the programme of the Annex I Experts Group. In total 68 participants from 22 countries, including 6 participants from 6 EIT countries, attended the workshop. Of the 68 participants, 24 were from government, 15 from research institutions, 8 from universities, 4 from industry, 2 were consultants and 15 were from the Secretariats.

2. Objectives

The objective of the workshop was to obtain insights for policy design and provide suggestions and guidance to policy makers and experts in Member countries on government policies to address the environmental impact of the building sector. The workshop was also intended to facilitate the exchange of information on experiences in Member countries and to discuss key issues such as barriers to effective policy and the choice of policy instruments. The results of the workshop will be reflected in the final report of the Sustainable Building Project of the OECD.

The building sector is concerned by various environmental issues, such as reducing greenhouse gas (GHG) emissions and other air pollutants, waste minimisation and resource conservation, the preservation of historical features, and the conservation of local natural areas. Among these issues, the reduction of GHG emissions, waste minimisation and the preservation of indoor air quality were chosen as the foci of the workshop.

Besides the introductory and closing sessions, a total of 7 sessions were organised. The main objective of the sessions on the first day (Sessions 1-A, 1-B, 2 and 3) was to examine the experiences of OECD countries in implementing policy instruments, and to obtain insights for the design of effective and efficient policies. On the basis of discussions on the first day, sessions on the second day aimed to examine some of the particular policy issues which arise in the building sector due to the structural characteristics of the sector, the nature of the building stock, and the environmental issues to be addressed.

3. Summary of discussions

This section contains a brief summary of the discussions and main findings from each session.

Introductory Session

The workshop opened with comments by the Deputy Director of the Environment Directorate of the OECD, Mr. Kenneth Ruffing, and the Director of the Energy Efficiency Program of the IEA, Mr. Hans-Jorgen Koch. These were followed by an introductory presentation by the Secretariat of the OECD to provide background for the discussions on policy design over the next two days. In this presentation, the main findings from recent analytical studies on the design of environmental policies for the building sector were outlined.¹

Session 1-A: Increasing energy efficiency and reducing GHGs in the building sector

Participants noted that in order to improve the energy efficiency of buildings, the long-term environmental impacts of buildings have to be taken into consideration at the early stages of the planning and design process because the energy efficiency of buildings greatly depends on the decisions made by investors and designers at these stages. However, those who invest in construction tend to be averse to the increase of capital and design costs, even when the increase is modest. Moreover, it is often argued that both the building industry and buyers of buildings tend to have a relatively short perspective on the benefits that energy efficiency improvements can bring, and consequently focus on reducing capital cost.

Building regulations, which have long played a central role in energy efficiency improvements, may be effective in defining basic minimum standards for energy efficiency performances of buildings. However, in practice, it is difficult to set standards that could be effective for the majority of buildings. It was agreed that governments need to implement other types of instruments that could provide prospective owners with incentives to improve energy efficiency.

A wide variety of non-regulatory instruments, such as information tools and economic instruments, were discussed during this session. One approach, which was found to have great potential, is environmental labelling for buildings. These schemes aim to make energy efficiency and other environmental performances of buildings more visible to potential buyers and users by assessing these performances with predetermined criteria. In the UK and Japan, voluntary labelling schemes are beginning to be widely used. Although the target and the structure of the schemes may differ, their experiences suggest that such schemes can improve the energy efficiency of buildings.

The possibility of establishing an international model for labelling schemes was also discussed during the session. However, it was pointed out that it is difficult to apply the exactly identical assessment criteria to

1. The presentation was made by Mr. Takahiko Hasegawa of the Secretariat based on the report "Policy Instruments for Environmentally Sustainable Buildings"[ENV/EPOC/WPNEP(2001)6].

buildings across the world, and such international model should allow for the reflection of regional contexts, such as climate and cultural background.

With regard to other non-regulatory instruments, Canada's experience suggests that a subsidy programme may be effective in improving building design; however, such a programme may require substantial financial resources if it is to affect a large number of buildings. It was also stressed that the possibility of applying an emission trading scheme to the building sector should be explored as this could have a large potential for reducing GHG emissions not only from new buildings, but also from existing buildings by encouraging the retrofits. Participants emphasised that governments should integrate a wide variety of policy instruments and create effective policy packages, rather than rely too much on a single instrument.

Session 1-B: Upgrading energy efficiency and reducing GHG emissions from existing buildings

Participants agreed that the existing building stock has a large potential for saving energy, and that governments should pay particular attention to developing policies for this sub-sector. Since fewer measures have been introduced for existing buildings than for new buildings, governments need to establish a new strategy and policy framework in this area. During the session, various factors were identified as barriers to improvement, including the uncertainty of energy cost and resale value, as well as the lack of information regarding energy saving potential. It was also stressed that the existing building stock is characterised by some unique factors, such as presenting technical difficulties for making energy efficiency improvement that makes the implementation of effective policies more difficult in this area.

Participants noted that governments are presently exploring various possibilities for improving the energy efficiency of the existing building stock. Since it may be politically difficult to extend to existing buildings the coverage of building regulations that have been widely used for the improving the efficiency of new buildings, governments have concentrated their efforts on introducing non-regulatory instruments.

Environmental labelling schemes for buildings are increasingly drawing the attention of policy makers. The evaluation of the mandatory labelling scheme in Denmark indicates that this approach has great potential, and that increasing public awareness of energy efficiency issues is key for the effective implementation of such schemes. It was reported that the UK is also considering using this approach in the near future. Germany is planning to provide financial incentives for upgrading the energy efficiency of existing buildings, but it was noted that this programme may require a methodology for policy impact assessment and substantial financial resources to be effective and attain policy objectives.

Since many of the policy instruments in this area have a relatively short history of implementation, their cost-effectiveness remains to be determined. Participants agreed that further studies on the cost-effectiveness of such instruments will be necessary.

Participants noted that the efficiency of policy instruments greatly depends on their combinations. For instance information tools, such as labelling schemes, may be more effective if they are combined with economic instruments that provide financial incentives for implementing measures that are considered to be highly efficient. Another point that was repeatedly emphasised by participants was the role of governments as owners of a large number of buildings. By implementing best practice upgrades in their buildings, governments can demonstrate the potential that energy efficiency upgrades of buildings can have.

Session 2: Reducing material use and waste generation in the building sector

While some pilot projects have demonstrated that it is technically feasible to recycle or reuse most demolition waste, and a considerable proportion of construction and demolition waste is currently being brought to landfill or incineration sites in many countries, various obstacles to promoting the recycling and reuse of building materials were identified during the session. Due to the long service lives of products used in the building sector, it is generally difficult to impose responsibility regarding the final disposal of these products on their producers. Furthermore, demand for recyclable waste does not always coincide with supply in terms of timing and geographical location. Consequently, recycling or reusing waste involves considerable transport and storage costs which make the final disposal of these low value, but bulky, materials more economically attractive. Also, users of building materials, designers and contractors sometimes hesitate to use secondary materials - unless there is proof of proper quality - for the fear that they may contain undesirable elements. Participants noted that there are a wide variety of approaches to overcome these obstacles. The most basic step for improving the resource efficiency of buildings may be to reduce the final disposal of wastes. In the Netherlands, the combination of a landfill tax and a ban on landfill have successfully reduced the amount of construction and demolition wastes that are brought to landfill sites. However, participants agreed that merely reducing final disposal is not enough, and that governments should aim to close the loop of the building materials flow by increasing the use of recycled/reused materials in the building sector. At present, most recycled building materials are used for construction projects that require materials of lesser quality, such as foundations in road construction, for which primary materials would not be used in most cases.

One of the measures that were discussed to close the building materials loop was introducing a take-back strategy. Despite the general difficulty of imposing responsibility for final disposal on producers, it was found that a take-back strategy could be introduced for some building components that have relatively short service lives. Similarly, it was stressed that the deconstruction of buildings, the removal of reusable components and materials from buildings before demolition, may have great potential. The standardisation of building components may help to promote the deconstruction and subsequent reuse of building components. However, it was pointed out that a high level of standardisation is difficult to achieve in the building sector that is generally characterised by heterogeneity in design and the use of a wide variety of materials.

Participants agreed that governments should take measures not only at the demolition and downstream stages, but also at the upstream design stage so that buildings are designed with consideration for their impacts on waste generation. However, changing the process of building design in the current building industry is difficult, and it was suggested that transforming the business model from product supplier to service provider may be necessary in order for environmental considerations to be reflected in building design. One measure that was proposed to facilitate this transformation was to incite firms to use reusable prefabricated building materials through government procurement programmes.

Session 3: Preventing indoor air pollution

Participants noted that people spend as much as 80-90% of their time indoors and that there is growing concern over health problems that are caused by long-term exposure to low-level indoor air pollution. Of the various types of indoor air pollution, the discussion of this session concentrated on pollutant emissions from building materials. It was found that there are so many factors that affect the indoor pollution level. For instance, pollutant levels can rise with the increases of temperature or humidity, or if products containing pollutants are present indoors.. Participants suggested that it is necessary for governments to examine further the causal mechanism with empirical surveys, such as those that are currently being

undertaken in France, Japan and the US. In light of the complexity of this problem, it was stressed that it would not be appropriate for governments to try to address the issue with regulatory instruments alone.

Since a wide variety of building materials are incorporated in buildings in different ways, owners and users of building may need specific information on the risk of health problems that their buildings may pose. However, they usually do not have access to such information. Designers and contractors may also need to know the environmental characteristics of building materials, but the building industry is characterised by a dominance of small firms that are generally slow to gain and provide up-to-date technical information. It was agreed that the provision of reliable information for both sides of the market is key to the prevention of indoor air pollution.

In addition to the target value of the indoor pollutant level established by governments and international organisations, information on the amount of pollutant sources contained in building materials is necessary for designing a healthy environment. It was found that labelling schemes for building materials have improved the environmental characteristics of building materials in Finland and Japan by encouraging competition among manufacturers while regulatory instruments, such as regulation on ventilation and building materials, have also played an important role. Furthermore, providing guidelines that describe how the choice of building materials and other design elements can affect pollutant levels may help designers achieve a healthy indoor environment by bridging the gap between information on building materials and the target value of the pollution level. It was agreed that governments should commit themselves to providing this information.

While the importance of information tools was highlighted, it was also suggested that economic instruments may not be very attractive in this area because there is little room for improving cost effectiveness through economic instruments. Moreover, it was suggested that governments should pay attention not only to the toxicological effects of indoor air pollution, but also to its sensory effects and its impact on the outdoor environment.

Session 4: Using information tools in the building sector

Many of the characteristics of buildings, especially environmental characteristics, are invisible, and can neither be recognised directly nor perceived through use. Consequently, it is often difficult for buyers to distinguish high-quality from low-quality products. It was suggested that governments should encourage the use of transparent methods for assessing and awarding high environmental performances of buildings. With the introduction of such methods, suppliers will be able to emphasise the strong points of their products and consumers can receive reliable information on the environmental performances of buildings. Participants noted that information tools, such as labelling schemes, are becoming more effective as awareness of environmental issues increases.

With regard to the German building sector, various aspects of labelling schemes for buildings were discussed. An important point that was discussed was to what extent governments should be involved in the establishment of such schemes. It was suggested that while government support is essential, semi-public organisations should take the initiative of establishing the framework of labelling schemes so that they will be widely accepted by stakeholders. It was also found that information can be conveyed to consumers in different ways under such schemes, ranging from “log-book” type of information to graded quality labels.

Participants noted that lack of information was one of the main obstacles to the development of a secondary building materials market. Three kinds of information-related barriers were identified: first, suppliers of waste may provide little information on the quality of their waste to their potential buyers;

second, examining the quality of waste and adapting building design to the use of secondary materials may be necessary and involve additional cost; and third, in some cases, users of secondary materials may not be prepared to accept the risk of using materials that could contain inappropriate substances, even if the perceived risk is significantly greater than the actual risk.

Participants also noted that governments need to implement several policy instruments to address these barriers. Waste information exchange schemes could reduce asymmetrical information by providing additional information for buyers without increasing the search cost. Demonstration projects and environmental labelling could help to reduce liability fears associated with secondary materials. It was also suggested that an appropriate combination of these information tools is necessary because different types of tools are required to address different information barriers. It was also pointed out that so far little evaluation has been carried out on the environmental benefits that information tools could bring and that more empirical studies should be done in this area in the future.

With regard to technology-related issues, there was a discussion on the approach that governments should take to foster energy efficiency improvements. On the one hand, it was suggested that policy makers should take into consideration the full range of new and emerging technologies that may be more efficient than currently available technologies, and try to make the best use of their potential. On the other hand, it was stressed that substantial improvement can be achieved by the diffusion of available technologies, and that the main barrier to energy efficiency improvements is due to a hesitancy to accept new technologies. Governments should therefore take measures to incite designers and consumers to accept new technologies. Participants also noted that governments have to take into consideration the sociological aspect of these processes when designing policies for the building sector.

Session 5: Targeting and co-ordinating policy instruments in the building supply chain

Participants noted that governments should play a key role in improving the environmental characteristics of buildings. There are a wide variety of policy instruments to choose from, not only in terms of different types of instruments, but also different stages of intervention and targets. The issue of targeting and co-ordination was discussed with regard to both energy efficiency and resource efficiency, and it was agreed that governments should take a holistic approach so that interdependencies and synergies between policy instruments can be developed. Although participants noted that governments need to implement policy instruments for both sides of the market, discussions in this session focused on the role of government can play in changing the behaviour of the building industry.

In the context of improving energy efficiency, it was stressed that governments need to declare ambitious long-term goals so that a broad consensus for long-term radical change can be established among stakeholders. On the basis of this consensus, an appropriate combination of regulatory instruments and other instruments should then be established. Regulatory instruments are more likely to be effective when they are designed with clear regulatory goals and a good empirical understanding of the factors that determine the performance of the built environment. Nonetheless, it is not easy for regulatory instruments to succeed in affecting the efficiency of the majority of buildings. Economic instruments, such as an energy tax, may provide an incentive to improve practices beyond levels required by regulation. It was also stressed that the effectiveness of such a tax depends greatly on the political consensus to maintain the tax in the long run.

There were some discussion regarding the aims and targets of government policies. Among the various elements that affect the energy use of buildings, it was emphasised that operational energy use should be the focus of policies. In particular, some participants suggested that existing buildings represent the sub-sector for which governments should develop their policies. On the other hand, it was also suggested that

policy instruments for new buildings could indirectly improve the efficiency of existing buildings. For instance, the improvement of energy efficiency standards in the UK in effect encouraged window manufacturers to stop the production of low-efficiency windows that had also been used in the refurbishment of existing buildings.

Participants agreed that governments need to address obstacles that hinder the diffusion of efficient technologies. Such obstacles could be found on both sides of the building market. On the supply side, many designers and contractors lack knowledge of how to improve the environmental characteristics of buildings. On the demand side, cultural attitudes of consumers sometimes obstruct the introduction of new technologies for improving energy efficiency, although these have been technically proven to be more efficient than existing technologies.

The discussion regarding resource efficiency highlighted the role that governments can play to incite producers to develop life cycle approaches for their products. Participants noted that a key for improving the resource efficiency of the building sector is applying ecological theory to the industrial system, which would help establish a closed materials loop.

Referring to the carpet tile industry in the US, which has voluntarily established a closed loop recycling mechanism, participants suggested that there is great potential for applying this mechanism to other product segments. Governments should be committed to developing policies that encourage the use of such mechanisms because these are less likely to be voluntarily adopted for building components that have longer service lives. It was also suggested that policy instruments for the industry should be coupled with incentives for consumers to choose products that will generate less waste. Participants noted that government intervention can easily be disintegrated across many levels and agencies of government, and that government intervention can be enhanced when it is co-ordinated not only within the government but also across different layers of government bodies. It was also suggested that international co-operation can accelerate, facilitate and complement national efforts.

Session 6: Assessment, monitoring and policy reform

Participants agreed that it is necessary to establish indicators and a framework for monitoring the environmental performance of buildings. However, the monitoring should not be done on an ad-hoc basis, and governments should establish an infrastructure for collecting and analysing information on the performance of buildings. This kind of monitoring mechanism may help policy makers and other stakeholders not only to understand the current situation but also to receive guidance for future action, and to contribute to the development of clear performance targets.

The environmental performance of buildings can be measured on different scales. For instance, the EU-based project CRISP aims to establish indicators of sustainability for the building sector at three levels: product, building and urban area. While discussions during the session focused on the importance of post-construction monitoring of buildings, all of three levels of monitoring may be relevant for designing policies. Under the current policy framework, most evaluation of the environmental characteristics of buildings is done at the design stage by checking the design documents, and in many countries there is no existing framework for monitoring how buildings are actually performing. It was suggested that an energy labelling scheme may help develop such a framework. A forthcoming EU directive will probably require EU countries to establish a mandatory labelling scheme that will cover not only newly-built buildings but also existing buildings that are on the market. It was also suggested that an adequate number of professional engineers would be required to make such schemes work effectively.

Participants also noted that the results from monitoring the energy performance of buildings will have to be analysed carefully. These results may indicate that the estimated energy saving has not been achieved, but this may be due not only to the performance of the building itself, but also to other factors, such as the difference between the predicted and actual behaviour of occupants, and unpredicted climate change, *etc.* It is important to note that unless monitoring results are carefully analysed with a broad perspective, they could provide inappropriate and misleading suggestions for policy makers.

Closing Session

With regard to future steps for improving policies for the building sector, participants agreed that it will be necessary for all relevant organisations and experts to continue the evaluation of present policy instruments, and analyse their actual effectiveness and efficiency. In particular, it was stressed that the close collaboration between experts on technical issues and those on policy design is essential.

Participants also pointed out several issues that should be examined further by policy makers and experts involved in the building sector. These include potential benefits that collaboration between government and industry could bring; how decisions of investors at pre-design stages could be influenced; developing measures to improve the operation of buildings; and conducting a sociological analysis of stakeholders' behaviour. Some participants pointed to the importance of continuing to exchange information on policy instruments, and examining how the best practices in a certain country can be transferred to other countries.

Participants also expressed their expectation that the OECD and the IEA - in collaboration with other organisations and experts involved in policy design - will continue their efforts in conducting various studies on the environmental impact of the building sector. In the closing remarks, the Secretariat of the OECD thanked all participants for contributing to the fruitful discussions, and the Japanese government and the Annex 1 Expert Group on Climate Change for their financial support. The Secretariat also explained that the results of the workshop will be reflected in the final report of the Sustainable Building Project of the OECD which is scheduled to be submitted to delegates next spring. The Secretariat of the IEA informed participants that in the future its activities will focus more on issues related to sustainable building.

4. Main findings and conclusions

The main findings and conclusions of the workshop were:

- Building regulations that have long played a central role in the energy efficiency improvement of buildings can have an impact on only a small proportion of newly-built buildings, and governments need to place more emphasis on economic instruments and information tools.
- Governments need to pay special attention to the development of policy instruments for existing buildings since these have great energy saving potential.
- Governments need to ensure that the standards set in their building regulations are flexible so that they do not obstruct the diffusion of new and more efficient technologies.
- The lack of information on the demand side is one of the main barriers to improving energy efficiency. Information tools, such as the environmental labelling of buildings, appear to have great potential for

improving the energy efficiency in both new and existing buildings, and in commercial and residential buildings.

- An energy tax may be effective for the improvement of energy efficiency if stakeholders are convinced that the tax will be maintained for the long term.
- A capital subsidy for energy efficiency measures can bring some results. However, such a subsidy usually cannot have an impact on a large number of buildings due to fiscal constraints.
- A landfill tax and regulatory instruments, such as a ban on landfill, can effectively reduce the amount of construction and demolition waste that goes to final disposal, but these do not necessarily encourage substituting primary materials with secondary materials. Other instruments need to be coupled with these instruments.
- Lack of information is one of the main barriers to the development of a secondary materials market; it is necessary to introduce information tools such as a waste information exchange, material certificates, *etc.*
- In order to improve resource efficiency in the building industry, it is important to explore possible measures at upstream stages to encourage the building industry to close the product cycle loop and take the ecological dimension into consideration in its product design.
- Furthermore, policies at upstream stages, the demolition stage and downstream stages should be well co-ordinated so that they can create synergies.
- The causal mechanism of indoor air pollution is complicated, and so it is often technically difficult to control the indoor air quality with regulatory instruments only.
- Environmental labelling of buildings or building materials appears to be effective for achieving a healthier indoor air environment.
- Governments need to monitor the environmental performance of buildings so that they can better understand the effectiveness of policy instruments and receive guidance for future improvements.
- It is necessary for governments to understand that no single instrument can solve all these problems, and that they need to take a holistic approach by integrating various instruments to create effective policy packages.
- Governments should help develop the demand for more environmentally friendly buildings through their procurement policies.
- With close collaboration between experts on policy design and technical experts, the evaluation of present policy instruments is necessary so that there will be more empirical evidence to indicate the effectiveness and efficiency of these instruments. Moreover, sociological analysis on the decision-making process should be intensified.

ANNEX I. FINAL AGENDA/ISSUE PAPER

**OECD and IEA JOINT WORKSHOP
THE DESIGN OF SUSTAINABLE BUILDING POLICIES**

**28 – 29 June 2001
Paris**

OBJECTIVES

In recent years more and more policy makers and experts concerned with buildings have become aware of the importance of the issue of environmental sustainability, and there have been many technical developments which have improved the environmental characteristics of buildings. In light of this, several workshops and conferences have been organised to exchange information on "best practice". However most efforts to date have focused on technical issues such as the development of new appliances or new design methods. As such, relatively limited time has been spent on the discussion of policy issues. While the development of new technologies is fundamental to improving the environmental characteristics of building activities, this should be coupled with the analysis of policy design. The policy dimension is particularly important for buildings because the sector's characteristics are such that environmental policies often need to be very different in nature from those used in other sectors.

The workshop will focus on the design of government policies for sustainable buildings, with the main objective being to obtain insights for policy design. It will facilitate exchange of information regarding policy experience in Member countries and the discussion among participants on key issues such as the choice of policy instruments and barriers to effective policy implementation. The results of the workshop will be summarised in a report and will provide suggestions and guidance to policy makers in Member countries on the design of sustainable building policies.

SCOPE OF DISCUSSIONS

The sustainability of buildings is related to various environmental issues ranging from reducing greenhouse gas (GHG) emissions and other air pollutants, waste minimisation and resource conservation, the preservation of historical features, and the conservation of local natural areas. Amongst these issues, the reduction of GHG emissions, waste minimisation and the preservation of indoor air quality were chosen as the foci of the workshop.

Thursday, 28 JUNE 2001

The main objective of the sessions on the first day is to examine OECD countries' experience in implementing policy instruments, and to obtain insights for the design of effective and efficient policies. Speakers are expected not only to describe instruments that have been implemented in their countries, but also to highlight the main perceived barriers to improvements and make a general assessment of the effectiveness and efficiency of the policies. Discussants will be asked to discuss the design of relevant policies in general and make suggestions and recommendations for improvements in policy design and implementation.

Introductory Session (9:00-9:45)

- **Welcome speech**
Kenneth Ruffing (OECD)
Hans-Jorgen Koch (IEA)
- **Introductory presentations**
Takahiko Hasegawa (OECD)
Policy Instruments for Environmentally Sustainable Buildings

The main outcomes of a recent analytical study on policy instruments for environmentally sustainable buildings will be presented by the Secretariat of the OECD. This study aims to analyse the merits and demerits of alternative policy instruments to address the environmental impacts of buildings. It does so by examining how theoretical arguments regarding the choice of environmental policy instrument can be applied to the building sector, taking into account the sector's unique characteristics. This presentation is intended to provide the background to help develop the discussions over the two days. The conclusions of this theoretical study are expected to be revisited in the light of OECD countries' practical experiences in the following sessions.

Coffee Break (9:45 – 10:00)

Session 1 Increasing Energy Efficiency and Reducing GHG's in the Sector (10:00-13:00)

In OECD countries, the building sector accounts for about 30% of primary energy use and it has often been pointed out that there is great potential to reduce greenhouse gas emissions by implementing existing energy efficiency measures. Since policy design for new and existing buildings may require different approaches, the two cases will be discussed separately in two sub-sessions. The scope of the discussion will include the building envelope and appliances usually designed as integral elements of the building – e.g. heating (air, water), cooling, ventilation, air conditioning and lighting. The discussion will cover both the residential and commercial building stock.

Thursday, 28 JUNE 2001 (cont'd)

Session 1-A Increasing Energy Efficiency and Reducing GHG's of new buildings (10:00 – 11:30)

- **Presentations by speakers**

Hiroto Izumi (Ministry of Land, Infrastructure and Transport, Japan)

Non-Regulatory Approach to the Improvement of Energy Efficiency of Buildings

Suzy Edwards (Building Research Establishment, UK)

BREEAM: a Tool for Environmentally Sustainable Building

David Shipworth (University of Reading, UK)

Designing Emissions Trading Systems to facilitate carbon mitigation projects in the built environment - Lessons from the design of the UKETS.

- **Presentation by discussant**

Nils Larsson (Natural Resources Canada and iiSBE, Canada)

Improving the Performance of Buildings: the Canadian experience

- **Discussion**

Most OECD countries have relied heavily on building regulations in bringing about energy efficiency improvements in new buildings. While building regulations may be effective measures to impose minimum energy efficiency standards on buildings, it is generally argued that such regulatory instruments are economically inefficient and provide little incentive for innovation. Economic instruments (e.g. emission taxes, tradable permits, deposit-refund, premium loans, etc.) are generally favoured by economists because in theory they could achieve a given overall reduction of GHG emissions with less cost and provide greater incentives for innovation. However, they are not widely used in this sector. Conversely, in recent years information tools, such as environmental labelling of buildings, have been increasingly used in OECD countries. It appears that these non-regulatory instruments have great potential to improve the energy efficiency of new buildings, although there is not much empirical evidence to indicate the effectiveness of these instruments in the sector.

Questions for discussion

- *In the absence of government intervention what are the main barriers to the improvement of energy efficiency of new buildings?*
- *To what extent should governments rely on building regulations in the future?*
- *Which instruments should be more widely implemented by governments?*

Thursday, 28 JUNE 2001 (cont'd)

Session 1-B Upgrading Energy Efficiency and Reducing GHG's of Existing Buildings (11:30 – 13:00)

- **Presentation by speakers**
 - Jeremy Eppel (Department of Environment, Food and Rural Affairs, UK)**
Reducing Greenhouse Gas Emissions of Existing Buildings
 - Jens Laustsen (Energy Agency, Denmark)**
Energy Labelling of Buildings in Denmark
 - Holger Wallbaum (Wuppertal Institute, Germany)**
Germany's National Climate Protection Programme and the role of the Trade Union for Building, Agriculture, Forestry and the Environment (IG BAU) within this context
- **Presentation by discussant**
 - Jennifer Thorne (American Council for an Energy –Efficient Economy, USA)**
Policy Options for Improving the Efficiency of Existing Buildings: Experience to Date in the United States
- **Discussion**

It is widely agreed that GHG emissions from the sector can not be reduced substantially by only implementing policy instruments for new buildings. Moreover, there is a general consensus that there is great potential for energy savings in the existing building stock. However, it is also widely perceived that effective and efficient policies for existing buildings are difficult to design. Not surprisingly, fewer policy instruments have been introduced for existing buildings than for new buildings. In general building regulations are applied to existing buildings only when there is large-scale refurbishment/remodelling work. Many existing environmental labelling schemes are applicable only to new buildings. Under such circumstances, it may be necessary to establish a new policy framework to upgrade the energy efficiency of existing buildings.

Questions for discussion

- *Why are improvements in the energy efficiency of existing buildings more difficult than that of new buildings?*
- *In the absence of government intervention what are the main barriers to the improvement of energy efficiency in existing buildings?*
- *Which instrument should be more widely implemented by governments?*

Lunch (13:00 – 15:00)

Thursday, 28 JUNE 2001 (cont'd)

Session 2 Reducing material use and waste generation in the Sector (15:00- 16:30)

- **Presentations by speakers**
 - Jeroen van der Waal** (Ministry of Housing, Spatial Planning and Environment, Netherlands)
TBA
 - Ken Sandler** (Environmental Protection Agency, USA)
U.S. EPA Construction & Demolition Debris Program
 - Tomonari Yashiro** (University of Tokyo, Japan)
Incentives for industrial ecology in building sectors
- **Presentation by discussant**
 - Gilli Hobbs** (Building Research Establishments, UK)
Resource Efficiency in Construction
- **Discussion**

The building sector is responsible for between one-third and one-half of total material flow in OECD countries. Consequently a significant amount of construction and demolition waste (C&DW) have been generated in this sector, potentially causing substantial environmental damage. Under such circumstances it is necessary to reduce C&DW by promoting the recycling and reuse of building materials. In order to meet this objective, an increasing number of countries have been implementing regulatory instruments such as bans on landfill disposal or the application of landfill taxes, which have the effect of reducing the final disposal of C&DW.

Even in countries where a high proportion of C&DW is being recycled due to the introduction of these instruments, most recycled building materials are not used for building construction but for road construction. In the light of the fact that the amount of C&DW is projected to increase rapidly for coming decades, it is important to achieve a more self-sustaining resource flow in the building sector by promoting the use of recycled materials in the building supply chain. It is often pointed out that designing for recycling/reuse strategy have great potential, but it is not yet clear how governments could promote the strategy in the design of buildings.

Questions for discussion

- *In the absence of government intervention what are the main barriers to the promotion of recycling/ reuse of building materials?*
- *Which instruments should be more widely implemented by governments?*
- *How can governments affect the design of buildings so as to improve waste-related performances of buildings (e.g. recyclability, durability, etc.)?*

Coffee Break (16:30 – 16:45)

Thursday, 28 JUNE 2001 (cont'd)

Session 3 Preventing Indoor Air Pollution (16:45 – 18:00)

- **Presentations by speakers**
 - Kaisa Kauko (Ministry of Environment, Finland)**
Preventing Indoor Air Pollution in Finland
 - Christian Cochet (CSTB, France)**
Ways for Indoor Air Quality Management Policy - French Examples.
 - Ken Sandler (Environmental Protection Agency, USA)**
U.S. EPA Indoor Environments Program
- **Presentation by discussant**
 - Shuzo Murakami (Keio University, Japan)**
Current Status of Indoor Air Pollution by Chemical Compounds in Japan and the Policy Measures currently taken by the Japanese Government
- **Discussion**

Residents of OECD countries spend as much as 80%-90% of their time inside buildings, and health problems resulting from indoor air pollution have become one of the most acute environmental problems related to building activities. A relatively high level of concentration of pollutants arising from the use of building materials containing harmful substances and the improvement of air-tightness for higher energy efficiency, can pose various health and comfort problems. Moreover, it is not easy to control indoor pollution since there are numerous factors affecting the levels (e.g. building materials, ventilation, materials of furniture, temperatures and humidity).

With regard to government policies, there appear to be two main approaches to addressing the problem. On the one hand, some European countries have included minimum standards on material use, ventilation and other factors in their building regulations. On the other hand, other countries have relied mainly on information tools such as the provision of technical information to consumers and builders. Economic instruments are not used in this area, perhaps because there may be little room to lower the overall costs for attaining policy goals through their use. Since this is a relatively new problem, a basic strategy to address the issue is still under the discussion in many OECD countries.

Questions for discussion

- *In the absence of government intervention, what are the main barriers to the prevention of indoor air pollution?*
- *Which instruments should be more widely implemented by governments?*
- *To what extent should governments rely on regulations?*

Friday, 29 JUNE 2001

On the basis of results of discussions on the first day, sessions on the second day will examine some of the particular policy issues which arise in the sector due to the structural characteristics of the sector, the nature of the building stock, and the environmental issues to be addressed. While many of the issues will have been touched upon in the discussions on the first day, the sessions on the second day should provide an opportunity for these concerns to be addressed in greater detail. In Sessions 4 and 5, two expert papers will be presented.

Session 4 Use of information tools in the building sector: (9:00 – 10:25)

- **Presentations of expert papers by invited speakers**
 - Andreas Blum (Institute of Ecological and Regional Development, Germany)**
“Building-Passport” – A Tool for Quality, Environmental Awareness and Performance in the Building Sector
 - Jane Powell (University of East Anglia, UK)**
Information, the key to sustainability?
- **Presentation by discussant**
 - Marilyn Brown (Oak Ridge National Laboratory, USA)**
The Design of Sustainable Building Policies: The Technological and Information Interface
- **Discussion**

Lack of information has been identified as one of barriers to the reduction of the adverse impacts of the building sector on natural and built environment. Economic theory supports the view that information tools could be effective when there is a lack of information (or information of inadequate quality) on either side of the market. As such, it has been argued that information tools have a large potential role to play in this sector. In fact various information tools (e.g. environmental labelling, energy audits, technology dissemination, waste information exchanges) have been introduced in OECD countries.

Although an increasing number of information tools have been implemented and some of them are widely used, it appears that their effectiveness has not yet been fully examined. There is little empirical evidence to indicate to what extent the introduction of these instruments have improved the environmental characteristics of buildings relative to what would have been achieved without the instruments.

The purpose of this session is to discuss how information tools should be applied to the building sector and to what extent they could be effective to cope with environmental issues.

Questions for discussion

- *In the absence of government intervention what are the main information-related barriers to achieve the three environmental objectives (GHG, C&DW and IAQ) in this sector?*
- *Which participants in the market are most affected by information-related barriers?*
- *What kinds of instruments should governments introduce to overcome these barriers?*
- *To what extent could information tools be effective means to bring about environmental improvements?*

Coffee Break (10:25 – 10:40)

Friday, 29 JUNE 2001 (cont'd)

Session 5 Targeting and co-ordinating policy instruments in the building supply chain (10:40-12:05)

- **Presentations of expert papers by invited speakers**
 - Robert Lowe (Leeds Metropolitan University)**
Reducing Carbon Emissions from the Building Sector - A Review of Technical Potential
Barriers to Change and Policy Instruments
 - Charles J. Kibert (University of Florida)**
The Role of Policy in Creating a Sustainable Building Supply Chain
- **Presentation by discussant**
 - John Gelder (NBS Services)**
Building Product Selection
- **Discussion**

The building supply chain is long, taking in a variety of firms and users with very different characteristics. In addition, various public policy measures affect the environmental characteristics of buildings. Accordingly, there is a wide choice of policy instruments in terms not only of types of instruments (e.g. regulatory tools, economic instruments, etc.), but also in terms of stages of intervention (e.g. design and construction, use and refurbishment and demolition), and their targets (e.g. consumer, designer, material producer etc.). Without question the choice of the point of targeting is quite crucial in the design of policy instruments for this sector and has a key role in determining policy effectiveness.

Moreover, it is widely argued that a more integrated approach is required to address environmental problems in the sector. A good combination of instruments may create synergies in the reduction of environmental impacts of the building sector, while inappropriate co-ordination of instruments may undermine the effectiveness and efficiency of each individual policy instrument.

The purpose of the session is to discuss how governments should target the main points of their intervention and co-ordinate policy instruments to establish environmentally effective and economically efficient policy packages.

Questions for discussion

- *Which stage and target should be the main points of government intervention for achieving the three environmental objectives (GHG, C&DW and IAQ) ?*
- *What sorts of combinations of policy instruments governments should (and should not) be used by governments?*

Lunch (12:05 – 14:05)

Friday, 29 JUNE 2001 (cont'd)

Session 6 Assessment, monitoring and reform of policies (14:05-15:20)

- **Presentation by a government speaker or an individual expert**
Andrew Warren (Association for the Conservation of Energy, UK)
 Improving the Energy Efficiency of Buildings
- **Presentation by discussant**
Pekka Huovila (VTT, Finland)
 Sustainability Indicators and Policy Monitoring
- **Discussion**

It is difficult to predict precisely the effects of policy instruments in advance of their implementation. Even an instrument which is initially as effective as anticipated, may lose some of its effectiveness due to changes in circumstances. Therefore in order to meet a given policy objective, governments need to regularly monitor and assess the environmental characteristics of the sector and the impacts of policy instruments, and to reform their policies (e.g. upgrading of standards, replacement with alternative instruments) flexibly and systematically when it is revealed that current policies are not sufficiently effective.

However in practice it is not easy to implement this strategy. It appears difficult to monitor precisely the environmental characteristics of buildings and determine how much improvement could be attributed to the introduction of a certain policy instrument. Indeed, in many countries there are few existing frameworks to monitor and assess policies for the building sector at all. Moreover the reform of policies is often hampered by time-consuming administrative processes, etc.

The purpose of this session is to discuss how governments should assess and monitor the sector in order to provide guidance for the further development of policies in the future.

Questions for discussion

- *How governments should monitor and assess their policies?*
- *What should be the criteria to assess the effectiveness of policy?*
- *How should governments reform their policies based on the result of monitoring and assessment ?*

Coffee Break (15:20 – 15:35)

Friday, 29 JUNE 2001 (cont'd)

Closing session (15:35-17:00)

The purpose of this closing session is to clarify the main outcomes of discussions in each session and discuss what have been the main findings of the workshop and what should be done in the next step for the further development of discussions on policy design in this area.

- **Briefing of main outcomes from discussants**
- **Comments from expert paper authors about main findings from the workshop**
- **Plenary discussion on workshop results**
- **Close of Workshop**

Questions for discussion

- *What are main findings from the workshop?*
- *What should policy makers and experts do to develop discussions on policy design in this area?*

ANNEX II. WORKSHOP PAPERS

Introductory Session

**POLICY INSTRUMENTS FOR ENVIRONMENTALLY SUSTAINABLE BUILDINGS
(CONCLUSIONS)²**

By Takahiko **HASEGAWA**

Principal administrator, National Policies Division, Environmental Directorate, OECD

1. Instruments for reducing CO₂ emissions

Regulatory instruments

- While not usually economically efficient, mandatory standards for the design of buildings appear to be the most dependable instrument for achieving a given goal of energy efficiency if effectively enforced. In general, they do not require a significant administrative cost due to pre-existing complementary regulatory frameworks, but there appear to be a trade-off between the effectiveness of enforcing regulations and administrative costs.
- Technology-based standards impose higher compliance costs than the least-cost solution and provide little incentive for innovation. However, the introduction of performance-based standards is likely to reduce the overall compliance cost to some extent and increase incentives for innovation.
- It appears to be difficult to effectively implement mandatory standards for existing buildings because they are unlikely to be accepted by stakeholders. Moreover, since there is not usually a regulatory framework in place for existing buildings, administration costs may be high.

Economic instruments

- Subsidies and tax credits for investments in energy-saving measures have the potential to improve the energy efficiency of new buildings, but they entail relatively high administrative costs. In addition, over time they may not be efficient due to the problem of “adverse selection”, whereby subsidies are granted to households which would have undertaken the investment in any case. For related reasons, it is unlikely that they could have a major impact on a wide range of building activities, because they require expenditures of tax revenue. Generally speaking, subsidies contradict the Polluter Pay Principle.

2. The analytical report “Policy Instruments for Environmentally Sustainable Buildings” [ENV/EPOC/WPNEP(2001)6] was presented at the workshop; this section outlines the main conclusions of the report.

- It is doubtful that premium loan schemes could have a large impact on the decisions of buyers of new buildings who have access to savings or capital markets. However, for buyers without adequate savings or access to capital markets they may be effective in the presence of imperfect capital markets.
- The introduction of subsidy programs, tax credit schemes and premium loan schemes for existing buildings entail more administrative costs than for new buildings, because energy audit services are required.
- Although views on the impact of energy prices on investment in energy efficiency measures are mixed, energy taxes can achieve the least-cost solution, provide continuous incentives to seek more cost-effective technologies and entail modest administrative cost.
- Tradable permit schemes can be implemented for the building sector by establishing a permit market for CO₂. If effectively implemented this appears to be the most certain and cost-effective way of reducing overall CO₂ emissions from the building sector. Moreover, if it is targeted at the level of carbon-bearing fuel and electricity providers, the administration costs will be low.
- Unlike other measures, energy taxes and tradable permit schemes have positive effects other than through direct improvements in the energy efficiency of buildings, such as the reduction of embodied energies in building materials. In addition they can have the same effect on existing buildings as on new buildings, without entailing additional administrative costs.

Information tools

- Due to the close association between private incentives to reduce energy costs and the public objective to reduce CO₂ emissions, environmental labelling schemes may have a relatively large potential role in this area. However, labelling schemes usually entail significant administrative costs.
- The labelling schemes can also have a large impact on CO₂ emissions from existing buildings if energy efficiency improvements are reflected in the resale market.
- Energy audits can be potentially effective if used with other measures. However the implementation of effective and efficient energy audit programmes entail significant administrative costs.

2. Instruments for waste minimisation

2.1 Instruments at upstream stages

Regulatory instruments

- Minimum standards for the performance of buildings with respect to waste generation (e.g. recyclability, physical durability, adaptability etc.) can be effective for improving these performances, but they may not be easy to implement because the design of technically reasonable, flexible and reliable standards is very difficult and they are not likely to be easily accepted by stakeholders.
- Due to the long-lived nature of buildings, it may be infeasible to assign contractors or designers responsibilities regarding the treatment of C&DW with deposit-refund schemes etc.

Economic instruments

- The provision of economic incentives for designing buildings with high level of waste-generation-related performances through subsidy programmes, tax credit schemes or premium loan schemes may improve the performances, but this requires a considerable amount of tax revenues and entails significant administrative cost. Moreover the design of technically reasonable, flexible and reliable standards is very difficult.

Information tools

- Including waste-generation-related performance in the criteria used by environmental labelling schemes may be the most realistic measure at an upstream stage. While significant direct environmental benefits should not be expected from such measures on their own, they could prepare the ground for developing other instruments at this stage.

*2.2 Instruments at the demolition stage**Regulatory instruments*

- Bans on landfill and the mandatory separation and mandatory delivery of waste to processing facilities appear to be the most effective measures to reduce waste disposal, and also contribute to the increased use of recycled materials in building construction and innovation in the use of recycled materials. However they may increase illegal dumping. In addition, such measures are unlikely to be economically efficient.
- By acting as a deterrent on illegal dumping, mandatory reporting of the destination wastes and licensing systems for demolition contractors may serve as useful complements to direct regulations on disposal activities.
- Demolition permit systems - which can be seen as a mixture of direct regulations and supplemental measures - appear to be quite effective in reducing waste disposal.
- Strict regulation on landfill sites may be effective for the protection of environmental quality in groundwaters and surrounding areas. They also have the potential to reduce the amount of waste disposed by indirectly increasing tipping fees. However the effectiveness of the regulation is uncertain.

Economic instruments

- Although the effectiveness of landfill taxes for the reduction of waste disposal is not so certain, experience in the UK and Denmark indicate that the tax can reduce C&DW effectively. The landfill tax may attain the least-cost pattern of encouraging waste reduction among demolition contractors or building sites, and provide continuous incentives for innovating more cost-effective way of reducing waste. However, they may increase illegal dumping.

2.3 Instruments at downstream stages

Regulatory instruments

- The implementation of minimum standards for the use of recycled materials at downstream stages is economically inefficient and entails significant administrative cost. Moreover it may be very difficult to establish standards which are both technically reasonable and perceived as fair by all stakeholders.
- Minimum standards for the quality of secondary materials or building products containing them may reassure potential buyers of the quality of secondary materials, but are economically inefficient and have adverse effects on innovation.

Economic instruments

- Virgin material taxes appear to have great potential to promote recycling in the building sector with modest administrative cost, but may not be easily accepted by stakeholders. Moreover, since the links between the material taxed and the externalities associated with ultimate waste generation can be weak (i.e. depending on how it is used, where it is disposed etc.) the instrument is not likely to be effective.
- The provision of economic incentives for using recycled material through subsidy programmes, tax credit schemes or premium loan schemes may promote the recycling of building materials, but this requires a considerable amount of tax revenues and entails significant administrative cost.
- Subsidies for the capital cost of fixed processing plants may be effective in making recycled materials cheaper and increase the demand for secondary materials, though this requires a considerable amount of financial resources for a certain period of time and contradicts the Polluter Pay Principle. Moreover, such measures are only likely to be efficient if investments in recycling plants face specific failures in capital markets which can not be removed.

Information tools

- Reliable certification schemes for recycled materials coupled with recommended specifications, may not only encourage the use of recycled materials but also help with the implementation of other instruments.
- It is doubtful that environmental labelling of buildings that indicate to what extent recycled materials are used can influence the decisions of potential buyers, because available evidence indicates that consumers usually pay little attention to the use of recycled materials. Moreover, in some cases the use of recycled materials may be perceived in negative terms by potential buyers.

3. Instruments for preventing indoor air pollution

Regulatory instruments

- It is technically not very feasible to enforce minimum standards on the actual pollutant level because it is very difficult to monitor the level in a great number of buildings.

- Technology-based standards for the design of buildings (e.g. ban on the use of a certain material, minimum air exchange rate) are the most dependable instrument when there is firm evidence that a certain pollutant could inflict serious health damages occupants. However they are economically inefficient because the flexibility in building design is limited.
- The implementation of performance based standards in terms of estimated pollutant level under standardised assumptions may improve the economic efficiency of the regulation on building design, though the use of the performance-based standards may entail significant administrative costs.

Economic instruments

- Economic instruments are not very attractive instruments for addressing indoor air pollution, because, given that acceptable levels of pollutant concentrations are likely to be the same in all buildings, there is little room to lower the overall costs for achieving these goals by introducing more flexible economic instruments.
- By imposing more liability for health problems due to buildings on designers and contractors, incentives to reduce the supply of buildings that may be detrimental to human health can be provided for them.

Information tools

- Environmental labelling schemes for buildings have significant potential for improving indoor air quality, though the administrative costs tend to be substantial. Labelling schemes with rank and index buildings may provide incentives for innovation.
- Certification schemes for building materials could not only help designers in the choice of healthier building materials, but also make other instruments work efficiently.
- Recommended standards for indoor pollutant levels may be a good starting point for making stakeholders aware of the potential risks of indoor air pollution, but these standards alone do not give adequate guidance as to how the problem could be prevented.

NON-REGULATORY APPROACH TO THE IMPROVEMENT OF ENERGY EFFICIENCY OF BUILDINGS

by Hiroto **IZUMI**

Director of Housing Construction and Improvement Division, Housing Bureau,
Japan Ministry of Land, Infrastructure and Transport

1 Introduction

It has been argued in Japan that the building sector is very important to realize sustainable society. For instance, the building sector accounts for approximately One-third of energy consumption including the constructing process. According to the OECD's survey, Japan is the only country that does not have energy efficiency standards such as thermal insulation or air tightness in its building regulation. Instead, the Japanese government has been trying to facilitate the supply of sustainable buildings by taking various measures such as giving incentives with premium loans provided by the Japan Housing Loan Corporation or introducing a new labelling scheme for new housing.

Since the premium loan and the labelling scheme may potentially impose a huge impact on both consumers and producers, the energy efficiency of housing could be improved effectively and efficiently without depending on the regulatory instruments.

2 Overview of premium loan by JHLC

Japan Housing Loan Corporation (JHLC) is a quasi government organisation under the supervision of the Ministry of Land, Infrastructure and Transport and the Ministry of Finance. The JHLC was founded in 1950 as an institution specialised in housing finance and has long provided long-term, low and fixed rate housing loan to a number of households that buy their houses or order construction of their houses to builders, with the objective to improve the living environment.

Out of 1,213,157 housing units newly constructed in Japan in the year 2000, about 30% of them, 364,496 units, were financed by the JHLC. The JHLC introduced the special premium loan scheme for energy efficient houses in 1980. The JHLC started providing loans with extra premiums for houses satisfying the recommended standard established by the Japanese government under the rational energy use act. Since then the government has upgraded the standard twice in 1992 and 1999, and the standard for the premium loan has also been reviewed and upgraded in parallel.

When designing policy instruments in this area , it is important to provide incentives to upgrade energy efficiency for consumers and producers. The premium loan scheme by the JHLC is designed to provide more advantageous loan for housing with higher energy efficiency. Interest rates and the scale of additional

loan varies depending on the level of energy efficiency as indicated in the table 1. The lowest interest is applied only when the 1992 standard is met and additional loan of 2.5 million yen per unit is applied to those meeting the 1999 standard. It appears that such a structure of the premium loan provide consumers and producers with incentives to upgrade the energy efficiency.

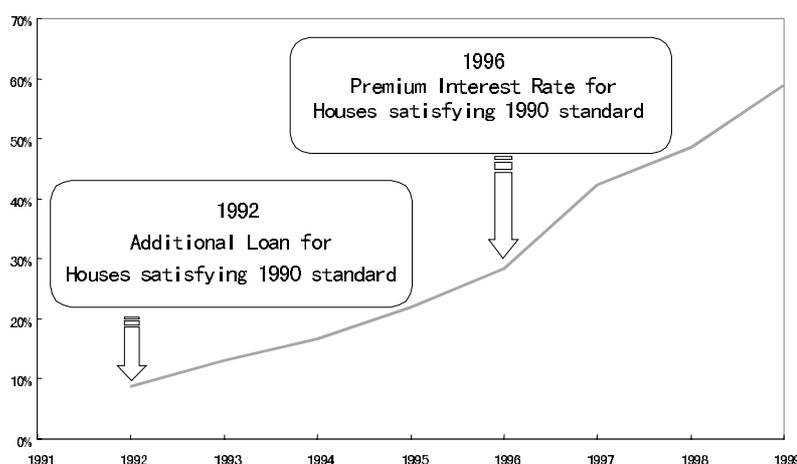
Table1; The premium given by the premium loan scheme by the JHLC

	Interest Rates (June 1 st 2001)	Additional Loan
>1999 standard	2.55%	2.5 million yen per unit
>1992 standard	2.55%	1.0 million yen per unit
>1980 standard	2.65%	-----
<1980 standard	(not eligible for JHLC loans)	

3 How the JHLC’s premium loan scheme could be evaluated?

Although there is no empirical data that clearly indicates to what extent the premium loan contributed to the improvement of the energy-efficiency of housing in relative to the situation without the scheme, some evidences suggest that the premium loan has been effective. The figure1 shows the proportion of houses satisfying 1992 standard to all houses financed by the JHLC, and indicates that the diffusion rate of energy efficiency was accelerated when premium interest rate was applied to these houses. This analysis is limited to those financed by the JHLC, but it is noteworthy that houses financed by the JHLC account for as much as 30% of all housing starts in Japan. Consequently it may be appropriate to say that the data are suggesting that the premium loan has been effective to some extent in the improvement of energy efficiency of housing.

Figure1 ; Proportion of houses financed by the JHLC satisfying the 1992 standard



One of the weakness of the premium loan may be that it is not so effective for improving the energy efficiency of rented housing. Although the JHLC has had a premium loan scheme for rented housing, the impact of this program has not been so large as that of owner occupied housing.

There is no empirical evidence to prove that the use of the premium loan is more economically efficient than the regulatory approach. However without regulations, those in the market can make more flexible choice regarding building design, including the choice of energy efficient measures. In theory this may reduce the total cost for the improvement of energy efficiency incurred by those in the market and provide more incentives to seek for more cost-effective technologies.

4 Overview of Housing Performance Indication Scheme

It has often been pointed out that consumers tend to lack the information on the performances of houses that they are going to buy, while those on the supply side, such as house builders, developers and contractors have good knowledge of the technical aspect of houses they supply. Moreover there were no standardised assessment criteria that could help consumers to understand the relative performance of houses.

Under such circumstances, it is difficult for consumers to make a rational choice, especially in Japan where there are wide varieties of houses in terms of structure and materials. As a result, 60% of housing purchasers thought they had not been given enough information on their houses upon purchasing. The Housing Performance Indication Scheme, introduced in 2000 under the Housing Quality Assurance Law, is intended to provide consumers with sufficient information concerning the performance of houses, that are evaluated by standardised criteria. The scheme is expected to enable consumers to make a comparison of performances between houses and make a rational choice.

Under the scheme, the government has developed evaluation criteria and has designated evaluation bodies to check designs and carry out on-site inspections. The scheme is not compulsory but voluntary, therefore, consumers and suppliers have a choice whether to use this new scheme. Each item of the evaluation criteria is indicated in a simple ranking manner in order for consumers to comprehend easily. (see Table2) The assessment items that consumers think much of varies depending on the preferences of individuals. The scheme does not indicate ranks for comprehensive or total evaluation. We did not introduce such item, because this might mislead the choice of consumers.

5 How the Housing Performance Indication Scheme could be evaluated?

Since its launch in October 2000, more than 11,000 houses have been evaluated under the Housing Performance Indication Scheme. It is likely that the number of houses evaluated under the scheme will increase as more house builders get prepared to use the scheme and more consumers become aware of the scheme. In general , labelling schemes like the Housing Performance Indication Scheme are expected to improve environmental characteristics of products by affecting consumers' choice in a way that more environmental friendly products are favoured. In the case of the energy efficiency, consumers may also have a private incentive to improve the efficiency that will lead to the reduction of energy costs.

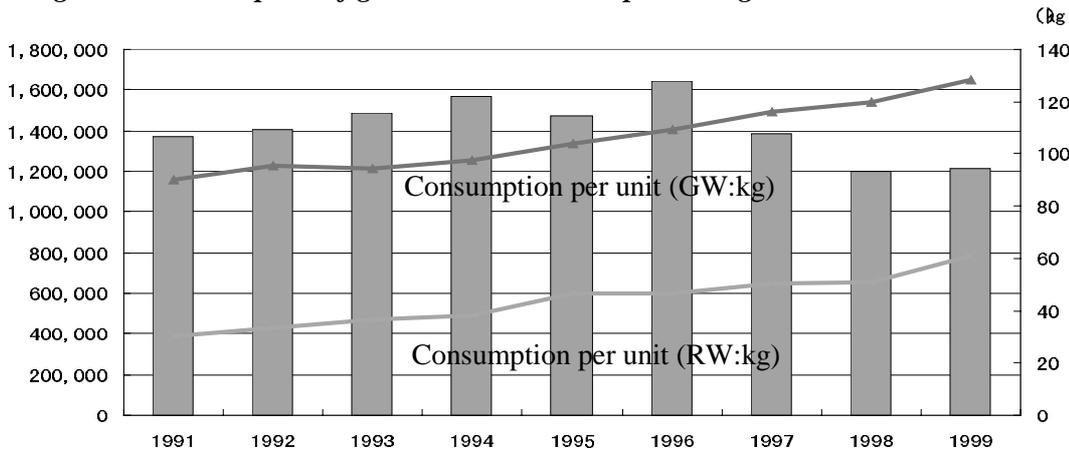
Table 2: Main performance items of the Housing Performance Indication Scheme

Performance items	Indication methods(criteria)	
Earthquake Resistance (Collapse resistance)	rank3 rank2 rank1	- 1.5 times as strong as the building code level or more - 1.2 times as strong as the building code level or more - the building code level or more
Earthquake Resistance (Damages resistance)	rank3 rank2 rank1	- 1.5 times as strong as the building code level or more - 1.2 times as strong as the building code level or more - the building code level or more
Durability	rank3 rank2 rank1	- can be used throughout three generations or more - can be used throughout two generations or more - can be used less than two generations
Energy efficiency	rank4 rank3 rank2 rank1	categorised in accordance with the heating/cooling burden
Fire safety	rank□ rank□ rank□ rank□	60 minutes for which external walls can resist fire 45 minutes for which external walls can resist fire 20 minutes for which external walls can resist fire
Safety for indoor Air pollution	rank□ rank3 rank2 rank1	categorised in accordance with the quantity of emission of formaldehyde from interior finish and backing
Sound insulation of floors	rank5 rank4 rank3 rank2 rank1	categorised in accordance with the thickness of floor slab, types of finish on floor etc.
Easiness for the maintenance	rank3 rank2 rank1	- pipes for sewage, water supply and gas can be maintained without damaging structural parts and finish - pipes for sewage, water supply and gas can be maintained without damaging structural parts - pipes for sewage, water supply and gas can not be maintained without damaging structural parts
Lighting	XX%	a proportion of total area of windows which receive sunshine to the floor area of the room
Friendliness for Elderly	rank5 rank4 rank3 rank2 rank1	categorised in accordance with the width of corridors, difference in level on floor, equipment of handrails in bathrooms, entrance and staircases, steepness of staircases etc.

As such it is important to examine to what extent the scheme has actually affected the decisions of consumers. However, since less than one year has passed since the start of the scheme, we have not found any empirical evidence which indicate the impact on consumers. On the other hand, some evidences are suggesting that the scheme has already had an impact on producers.

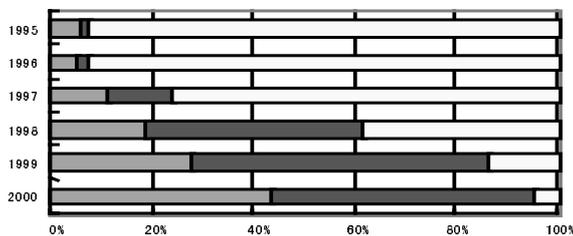
Figure 2 shows the trend of glass-wool/rock-wool consumption per housing unit, that may be a good indicator of the average energy efficiency of Japanese houses. The consumption has been increasing since the scheme was first proposed in 1995. It has been argued that the proposal of the scheme may have encouraged the improvement of the energy efficiency.

Figure 2. Consumption of glass wool/ rock wool per hosing unit



The impact of the scheme on producers can be more clearly identified in the market of particle-boards that have been regarded as one of the main sources of indoor air pollution. As shown in figure3, the market share of the low formaldehyde type (E0 & E1) has risen from 7% to 96% during the three years of time.

Figure3;Share of low -formaldehyde type particleboard (E0,E1)



6 Conclusion

In order to provide reliable information on the evaluation of houses, it is necessary for third parties to check the design documents and conduct on-site inspections. This inevitably requires some administrative costs. Since this is a voluntary scheme and all administration costs are incurred by those who make an application for the assessment as an application fee, it is required to minimise the administrative cost so as to diffuse the scheme. The inspection systems for this scheme was designed so as to minimise the cost. Private firms approved as an inspection body can conduct the evaluation, including check on design documents and on-site inspection, under the Housing Performance Indication Scheme. Before the introduction of this scheme, similar checks and inspections had been conducted by local authorities that are responsible for inspections for building regulations and entrusted to do inspections for the premium loan by the JHLC.

Apparently it is inefficient for different organisations to conduct similar design checks and on-site inspections. Therefore, the government has made local authorities and the JHLC to entrust some of the works to private firms approved as inspection bodies for the Housing Performance Indication Scheme. By doing this, it has become possible for only one expert from one organisation to conduct on-site inspections for building regulations, the JHLC's loan and the Housing Performance Indication Scheme at the same timing.

Moreover, it is necessary to facilitate the competition between inspection bodies so as to make them work in the efficient way. For this purpose there is no limit to the number of inspection bodies and the government is supposed to approve any private firms if they meet approval standards set in the law. In fact, more than 80 bodies have been already approved.

BREEAM: A TOOL FOR ENVIRONMENTALLY SUSTAINABLE BUILDING

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Introduction

This paper describes BREEAM, the leading assessment and labelling tool for environmental performance of building. Whilst the strength of BREEAM lies in its market focus, examples are given of the use of BREEAM as a policy instrument to improve the environmental characteristics of buildings. The paper also briefly describes to what extent the use of the BREEAM has actually affected the energy efficiency of buildings and empirical evidence is provided that indicates to what extent BREEAM has been effective in improving the energy efficiency.

What is BREEAM?

BREEAM is a system for assessing the environmental performance of buildings. It stands for 'Building Research Establishment Environmental Assessment Method'. For over a decade, BREEAM has been applied to new and existing buildings. Its success stems from the ability to cover a wide range of environmental issues within one assessment, and to present the results in a way that is transparent and easy to understand.

How is BREEAM assessed?

BREEAM assesses the performance of buildings in the following areas:

Issue	Description
MANAGEMENT	Overall policy, commissioning and procedural issues
ENERGY USE	Operational energy and CO ₂ issues
HEALTH AND WELL BEING	Indoor and external issues affecting health and well being
POLLUTION	Air and water pollution
TRANSPORT	Transport related CO ₂ and location related factors
LAND USE	Greenfield and brownfield sites
ECOLOGY	Ecological value of the site
MATERIALS	Environmental implication of building materials
WATER	Consumption and water efficiency

For each of the categories set out above, the building is assessed against performance criteria set by BRE and awarded “credits” based on the level of performance. The percentage of credits achieved under each category is then calculated and environmental weightings are applied to produce an overall score for the building. The overall score is then translated into a BREEAM rating of: pass, good, very good, or excellent. The BREEAM rating is presented on a BREEAM Certificate, which can be used to promote the environmental credentials of an organisation.

Latest Developments in BREEAM

BREEAM is continually being developed, reviewed and updated to ensure that it takes into account the latest research, technological developments and legislation. The version of BREEAM that applies to Offices is currently being revised. It has been revised three times, the latest version having been launched in 1998. EcoHomes, (BREEAM for homes) was launched on 6th April this year and BREEAM is currently being developed to cover more building types, including Retail developments.

Types of buildings that are covered at present are Offices (new and existing), Homes, Superstores and Industrial Units. BREEAM concepts have recently been developed for application to National Health buildings in the form of a tool called NEAT.

How can BREEAM be used?

Clients and design teams can use BREEAM in a number of different ways. Clients can use BREEAM to specify the environmental sustainability performance of their buildings in a way that is quick, comprehensive and visible in the marketplace. Letting Agents can use BREEAM to promote the environmental credentials and benefits of a building to potential clients whilst design teams can use BREEAM as a tool to improve the performance of their buildings and their own experience and knowledge of environmental aspects of sustainability.

What are the benefits of BREEAM?

The business benefits of BREEAM are clear and were identified in an independent marketing survey commissioned by BRE. They are:

Applications

Benefit identified

ENVIRONMENTAL IMPROVEMENT	In support of a wider corporate strategy or as a stand alone contribution
OCCUPANT BENEFITS	To create a better place for people to work and live
MARKETING	As a selling point to potential tenants or customers
FINANCIAL	To achieve higher rental incomes and increased building efficiency
BEST PRACTICE	To provide a thorough checklist or tool for comparing buildings
CLIENT REQUEST	Responding to the requirements of the users

Costs of implementing BREEAM

BREEAM is a self sufficient tool. Fees are paid by clients to assessors. A number of BREEAM assessors have been trained and licensed, generating an income to BRE for quality assurance, marketing and a contribution to the development of new versions.

BREEAM and Policy making

BREEAM is a voluntary tool and as such is not part of national policies to reduce environmental impacts from buildings. It is managed so that it continually stays ahead of requirements in national Building Regulations.

Government as a Construction Client

About 40% of the construction industry output by value (some £24 billion a year) is purchased by the public sector. The Governments recognises its responsibility as the industry's' leading client to set an example in the sustainable procurement, maintenance and operation of its built assets.

To help achieve this, all central Government construction clients have endorsed a programme for more sustainable construction procurement. By 2003, all Departments and Agencies must have adopted the Action Plan on Sustainable Construction, which sets targets which they must monitor and report progress.

One of the Action Plan targets is a rolling programme relating to BREEAM. By 2001, all new buildings must achieve a rating of Good (or better), by 2002 all new buildings must achieve a Very Good, major refurbishment a Very Good and by 2003, all Departments and Agencies are to achieve an Excellent rating for new buildings and Very Good for major refurbishment. BREEAM for existing buildings is available and there are no targets to use this. However, recommendations to use this are made as part of the Governments wider in-house commitments to building management.

The Local Government Task Force is developing a similar approach for local authorities to apply to their construction procurement. The UK Housing Corporation makes available an increased grant for public sector housing for those implementing environmental measures. Ecohomes is used as evidence of such measures.

BREEAM and Energy Efficiency

CO₂ emissions received the greatest weighting in a BRE exercise to rank the importance of different environmental impacts. This set of weighting is used to inform the way in which BREEAM credits are achieved. 25% of credits available come from energy related issues. As such, those wishing to achieve a high score are likely to place a great deal of emphasis of on reducing their energy consumption, meaning that BREEAM acts as a powerful incentive for the creation of energy efficient buildings.

The specific energy efficiency attributes included in BREEAM include levels of predicted CO₂ emissions, measured in kg/m²/yr. The range is from 160kg/m²/yr to less than zero (i.e. net CO₂ consuming buildings).

BREEAM'ed office buildings on average produces 27% less Carbon Dioxide emissions than good practice and 60% less than typical UK office development.

This assertion is based on a standard air-conditioned office building in the UK with typical size ranges of 2000m² – 8000 m². Such buildings are largely purpose built and often speculatively developed.

Typical CO₂ emissions = **140 kg/m²/yr**

Good practice CO₂ emissions = **77 Kg/m²/yr**^[1]

Average CO₂ emissions for the same building type with BREEAM = **56 Kg/m²/yr**^[2]

When considering such figures, it is worth bearing in mind that the BREEAMed buildings are assessed at the design stage, so the figures are predicted and not actual.

Cost savings

Based on typical energy consumption figures and the costs of energy at 2000 prices a BREEAM'ed office building can expect annual energy costs to be around £5/m². This is almost two thirds less than that of a typical office development. Annual energy costs for a typical office development of this type are £14/m², good practice office development is £8/m²^[1].

Since 25% of new commercial office buildings have received a BREEAM rating, this represents a significant improvement to the UK building stock. As the "existing buildings" certificate of BREEAM increases in popularity, it is to be hoped that they too will demonstrate improvement.

As well as net emissions from energy use, energy management also receives credits. Examples of management techniques recognised within the tool include:

• sub-metering of substantive use areas and plant,
• check metering in tenancy areas,
• good practice energy policy in place and regular audits
• dissemination of energy savings
• energy/CO ₂ monitoring and targeting
• full maintenance systems for building services and light fittings

Relationship with other tools

A diverse range of tools can be a problem when setting policy in environmentally sustainable design. BREEAM is a well recognised "brand" for environmentally sensitive building design and increasingly provides a common "umbrella" for the use of other tools. Because they are linked to BREEAM, it should be easier for other tools to penetrate the market place and take a role in environmental building policies. Such tools range from the initial design environmental estimating software tool, ENVEST^[3], to the Checklist for Sustainable Developments. Envest provides a measurement of the embodied environmental impact of materials (measured in Ecopoints) and shows their relationship to operational energy of the building. BREEAM is also linked to a Property Portfolio Environmental Benchmarking tool and the UK Considerate Contractors scheme: the links are diverse and ensure a common approach to sustainable construction.

Conclusion

BREEAM is one tool amongst many available to help improve the energy efficiency of buildings, including a wide number of best practice guides and assessment schemes prepared under the Energy Best practice programme in the UK. What makes BREEAM special is that it provides market focused recognition for those who have improved their performance, helping to achieve demonstrable business benefits. In addition, it provides a link to wider issues of sustainability: as well as providing an incentive to reduce energy efficiency in the building, BREEAM also raises awareness of the need to reduce energy use in transport to the building, to reduce other resource and consider wider sustainability issues including water use, health issues, and material efficiency.

References and Further information

[1] The Government Energy Efficiency Best practice programme, Energy Consumption Guide 19. 2000 – Crown copyright.

[2] Source: Carbon Dioxide figures from 35 BREEAM assessed office buildings. BRE 2001

[3] www.bre.co.uk/envest

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**IMPROVING THE PERFORMANCE OF BUILDINGS:
THE CANADIAN EXPERIENCE**

by Nils **LARSSON**

Natural Resources Canada and iiSBE

A frequent point of debate is the relationship between Green Building and Sustainable Development (SD). We take the view that SD is most applicable at the urban or societal level, since it includes issues of social equity and broad issues of economics, in addition to concerns about ecosystems and human health. We find it difficult to apply these broader societal issues to buildings in a practical way. Instead, many building researchers and designers find it more meaningful to develop models of building performance that is consistent with SD at the societal level. In short, Green Building helps to support a broader Sustainable Development agenda.

If Sustainable Development goals are to be truly reached, we could argue that buildings should consume no energy, water or materials, and should produce no emissions, noise or waste over their lifespans. While this is an interesting concept, it is likely that we will have to work towards more modest goals during the next 20 years.

Even at a more realistic level, there is global interest in improving the performance of buildings. Governments want to reduce the use of scarce resources and airborne emissions, owners want to reduce operating costs, and developers are finding that customers are demanding higher quality and performance.

Although the achievement of this goal in different countries will require varied strategies, it is certain that all will have to make substantial improvements in the methods used to design, construct and operate buildings. This will require interventions by governments, but it will also require that designers adopt a different way of working.

The building industry is very different from other sectors with substantial environmental impacts. The performance of automobiles, for example, can be improved by working with relatively few manufacturers, but the construction industry consists of thousands of organisation, ranging from very small to very large, and staffed by individuals whose levels of skills and training vary from very basic to quite advanced. Buildings are also long-lived compared to other products, and have to conform to local cultural and climatic conditions in addition to meeting functional requirements. All of this implies that initiatives for performance improvement must be addressed on a broad front.

This paper will confine itself to the range of initiatives that look promising in the large buildings sector (excluding small houses) and within market economies. In addition, the discussion will be focused on measures that apply primarily to the design and construction stages, for both new and renovated buildings. All the approaches discussed are based on Canadian experience, but their basic strategies are of broader interest.

Options in Improving Energy and Environmental Performance

Any discussion of building performance must recognize that designers carry out instructions provided by their clients. Thus, an appropriate focus is to consider ways through which clients might be induced to require their designers to strive for a higher level of performance. The range of mechanisms available include regulations and standards, enabling measures, incentives and market change mechanisms.

Standards and Regulations can be very effective if well enforced, but they usually define a minimally acceptable level of performance and are therefore normally insufficient to lead the industry towards very high levels of performance. Canada has much recent experience in this area due to the development and introduction of equipment efficiency standards and the *Model National Energy Code for Buildings* (MNECB)¹. Standards for equipment have been in place for several years, and are complemented by an equipment labelling program called *EnerGuide*, which provides information about the energy performance of the item under normal usage conditions. The *EnerGuide* program is about to be supplemented by the adoption of the *Energy Star* program (originally from USEPA), which identifies the top-performing equipment in each category.

The design of the MNECB regulatory package for buildings is sophisticated, since it allows for both default minima and a simulation path for compliance, and also takes into account energy costs and incremental construction costs within a life-cycle cost formula. Studies have shown that the NECB is approximately congruent with current good practice but, despite this, only a few jurisdictions in Canada have adopted it because of industry resistance.

The difficulty of implementation reflects a peculiarly North American context, where regulations have traditionally confined themselves to issues of life safety and health. Any extension of the regulatory sphere is therefore considered by the North American industry to have validity only if measures reflect a strong consensus on a minimum level of action. This, combined with very low energy prices over the last decade, have made it difficult to build a consensus for strong action in the area of energy. Nevertheless, the MNECB is gradually taking root, but at a level of performance which is relatively unchallenging.

What may be called *enabling measures*, such as the development of guidance documents, design tools, and training programs, are also necessary components of a green building strategy. Such measures tend to be used by those in the industry who are already convinced of the need for high performance, and so they tend to have limited penetration, but some recent developments in design process support tools show promise (discussed later in this paper).

Demonstration projects fill a very important part in convincing the relatively conservative construction industry that modern processes and technologies can bring benefits. Where demonstrations fail, this is possibly even more useful, although there is a tendency to sweep such findings under the carpet. The C-2000 Program is currently the only available national demonstration program in North America.

Financial incentives are of interest, since a financial inducement is likely to be effective in an environment where financial return is a primary objective. One example is a program called *Commercial Buildings Incentive Program*, or CBIP. For buildings passing the threshold of 25% improvement over MNECB requirements, this program provides incentives of two times the projected energy costs savings of the building, up to a maximum of \$60,000 CAD. Approximately 800 projects are now enrolled in the program and it is well received by the industry. For all the success of CBIP, however, the fact remains that to extend the program to, say, 25% of the new building production would not be feasible because of the total costs involved.

1. National Energy Code for Buildings; National Research Council; Ottawa, 1995.

Another national Canadian program uses financial support at a more strategic level. The *Energy Innovators Initiative* was launched in 1992, and is intended to influence eight strategic sectors in the industry by providing financial support to large organisations that own very large buildings or a large number of similar buildings. The program engages corporations at the CEO level through an agreement that provides support for the development of a corporate-wide energy efficiency strategy, and also pays for part of the cost specific performance improvements in a pilot building that can be replicated in other similar buildings later. This approach is a very effective way of changing the industry, since the targeted major organisations have considerable influence in their own sector. Over the past three years, about \$9.2 million CAD was provided to 52 organisations, resulting in an aggregate CO₂ reduction of 175 kt per year.

The *Federal Buildings Initiative* (FBI) applies the principle of energy performance contracting to buildings owned by the Federal government. In the performance contracting approach, specialised energy companies estimate the energy that may be saved in existing buildings through the upgrading of lighting, the building envelope, equipment and other energy-consuming elements. The contractor finances the work and is repaid through savings in energy costs. The FBI program uses the approach in government buildings, and has been operational since 1991. The current program emphasis is on the reduction of energy consumption, and on the use of "green" energy sources. Some 70 contracts are in place, covering about 6,500 buildings that yield an annual energy cost saving of about CAD \$26 million.

The question remaining is what measure(s) might be implemented in addition to the existing repertoire of programs, that would move all or most of the industry players to reach significantly higher performance levels, and in a broader range of performance issues than just energy.

In the field of commercial building, developers and owners are very sensitive to market signals, and if measures could be developed to *affect market demand* in the right direction, they would certainly pay close attention. The first part of a solution is to convince actors on the demand side (investors and tenants) of the advantages and need for improved energy performance and reduced emissions. This will be an on-going matter of information and education, which will not be dealt with here.

The second part of a market demand solution is relevant, however. The fact is that even those investors and tenants who are already convinced about the need for high performance, do not generally possess the knowledge to define their needs in a clear way. In fact, even building professionals disagree on the exact meaning of performance, so it is not surprising that non-specialists are in an even worse position. It is clear that we need to develop mechanisms, to allow users to differentiate between buildings of varying performance levels. In other words, if an investor or tenant wants to buy or rent a high-performance building, then we must give him a way of identifying which buildings meet his needs. Methods and software (which we refer to as "tools") for performance assessment and labelling can fill this need.

A Closer View of Two Programs

The commercial buildings industry is driven almost exclusively by considerations of capital cost and return on investments. his fact, combined with the very low cost of energy during the 1990's, make it difficult to move the industry towards very high levels of energy performance.

Two programs from Natural Resources Canada have previously been mentioned as being of relevance. Highlights of each include:

Table 1: Overview of Characteristics of C-2000 and CBIP Programs

Program	C-2000 Program	CBIP Program
Number of projects to date	8 built or underway, 14 designed	800+ underway or complete
Annual Budget	Approx. \$200,000 CAD	Approx. \$5 million CAD
Performance areas	Energy consumption Environmental Loadings Indoor environment Functionality	Energy consumption Greenhouse Gas emissions
Energy target	45%-50% better than MNECB	25% better than MNECB
Current incentive/support	Varies from \$5k to \$25 k	2 times annual predicted energy cost saving, up to \$60 k
Comments	MNECB stands for the Model National Energy Code for Buildings	

The C-2000 Program

The C-2000 Program was designed in 1993 as a small demonstration of very high levels of performance. Even though it was aimed at a select group of clients known to have an interest in high performance, it was assumed that some level of financial incentive would be required to make the program a success. However, the extent of incentives required and the best point of intervention within the project development process was very much open to question.

C-2000 technical requirements covered energy performance³, environmental impacts, indoor environment, functionality and a range of other related parameters⁴. It was therefore expected that incremental costs for design and construction would be substantial. After a preliminary analysis of current project costs and an informal survey of designers, provision was made for support of incremental costs in both the design and construction phase. Contributions were provided according to a sliding scale ranging from 7% in large projects to 12% in small projects.

The first two C-2000 projects received support according to this formula in the range of \$400,000 to \$750,000 CAD, and funding of this order of magnitude was also planned for subsequent projects. However, after the first six projects were designed and two of them had been completed, it was found that that incremental capital costs were less than expected, partly due to the fact that designers used less sophisticated and expensive technologies than anticipated⁵. A careful investigation of the first two C-2000 projects constructed, Crestwood 8⁶ and Green on the Grand⁷, indicated that the marginal costs for both projects, including design and construction phases, was 7%-8% more than a conventional building, a rather modest increase. Even more interesting, the designers all agreed that application of the integrated design

3. At the time, the energy requirement was 50% better than the ASHRAE 90.1 standard (the benchmark is now the Model National Energy Code for Buildings, MNECB). Both are North American standards for good practice.

4. *C-2000 Program Requirements*, N. Larsson Editor; Natural Resources Canada; Ottawa, October 1993, updated April 1996.

5. The conservative preferences of designers is based primarily on their perception that they might face legal liability problems if they use exotic and unproven technologies.

6. *Technical Report on Bentall Corporation Crestwood 8 C-2000 Building*, April 1996, CETC, Natural Resources Canada.

7. *Technical Report on Green on the Grand C-2000 Building*, April 1996, CETC, Natural Resources Canada.

process required by the C-2000 program was the main reason why high levels of performance could still be reached. It also appeared that most of the benefit of intervention was achieved during the design process.

This turn of events led to changes in the C-2000 Program, so that financial and technical assistance was henceforth only provided for the design process, to cover costs such as the provision of a design facilitator and subject experts, energy simulations, and extra design time for the core design team. The C-2000 process is now called the *Integrated Design Process (IDP)*, and most project interventions are now focused on providing advice on the design process at the very early stage. Six projects have been constructed on this basis, and all have achieved the C-2000 performance requirements, or have come very close, and capital costs have been either slightly above or slightly below base budgets. The most hopeful sign that the IDP approach is taking root is that several owners have subsequently used the same process for buildings that have not benefited from any subsidy.

Specifically, the following C-2000 requirements have proven to be important:

- Inter-disciplinary work between architects, engineers and operations people right from the beginning of the design process;
- Discussion of the relative importance of various performance issues and the establishment of a consensus on this matter between client and designers;
- The provision of a Design Facilitator, to raise performance issues throughout the process and to bring specialised knowledge to the table;
- A clear articulation of performance targets and strategies, to be updated throughout the process;
- The use of energy simulations to provide relatively objective information on a key aspect of performance;
- Documentation of major steps and issues raised in the process.

Simple software design support tools have been produced to help design teams enrolled in the C-2000 program. One outlines generic design steps and provides a simple way for designers to record their performance targets and strategies; another facilitates the task of having the client and design team reach a consensus on the relative importance of various issues. The C-2000 IDP process is now being used as a model for development of a generic international model, by Task 23 of the International Energy Agency, and discussions are underway with the Royal Architectural Institute of Canada (RAIC) to see if the process can be accepted as an alternative form of delivery of professional services.

The Commercial Buildings Incentive Program (CBIP)

In 1997, it was decided to launch a larger national program to move the industry towards energy efficiency. Based on the lessons learned in C-2000, it was decided to focus the financial incentives of new CBIP program on providing incremental costs for the design process. However, several changes in approach were necessary for a program that was intended to be delivered to a large number of clients on a "hands-off" basis. This meant primarily that the program had to be simplified so that customized support would not be necessary. Specifically, this resulted in a narrowing of objectives of CBIP to energy only and a reduction of required performance threshold to a 25% improvement over the MNECB, rather than the

50% required for C-2000. However, the philosophy of placing emphasis on supporting the design process only was retained⁸.

The funding available for the CBIP Program was established as two times the predicted annual energy costs, with a maximum incentive level of \$60,000. An analysis of preliminary results in the CBIP Program presented in *Advanced Buildings Newsletter*⁹, showed that, as of the Fall of 1998, typical CBIP projects were receiving funding in the range of \$35,000, because their performance and/or size did not enable them to reach the maximum amount.

It should also be noted that the C-2000 and CBIP Programs are now being combined, so that almost all new C-2000 Projects also participate in the CBIP Program. Current C-2000 projects currently receive total financial assistance in the range of \$5,000 to \$25,000 during the design process only, a considerable reduction from past support levels. However, the combination of programs results in customized support and a total maximum available financial support of up to \$100,000 for a small number of projects each year.

Recently a third element has been added to the program mix. The Renewable Energy Deployment Initiative (REDI) has been established by NRCAN to promote the adoption of renewable technologies, and program staff have developed software that provides an assessment of the technical and economic potential for renewable energy technologies. Both C-2000 and CBIP staff are now encouraging consideration of renewables at an early stage in their projects.

Performance Assessment and Labelling Systems

During the last ten years considerable research has been focused on the development of systems to assess the environmental performance of buildings. Several of these systems have gone the next step, to result in a labelling system that indicates clearly the building's approximate performance to end users. It is best to say "approximate", since building performance includes many factors, only some of which are measurable in an exact sense.

The best-known existing system is undoubtedly the *Building Research Establishment Environmental Assessment Method* (BREEAM), developed by BRE and private-sector researchers in the U.K. This system provides performance labels suitable for marketing purposes, and has captured around 15% to 20% of the new office building market in the U.K. A spin-off system, BREEAM Canada, has been adapted to Canadian conditions, and a North American version is now being developed. Meanwhile, the LEED system has been developed in U.S.A. and is now being implemented by the US Green Building Council, with strong support from U.S. government agencies and private-sector organisations. Several other systems (largely inspired by BREEAM) are in various stages of development in Scandinavia, Hong Kong and elsewhere. There are also more specialised systems of interest that are more closely tied to Life Cycle Assessment (LCA), including ECO QUANTUM (Netherlands), ECO-PRO (Germany), EQUER (France) and Athena (Canada).

Why is there so much interest in this area? The main reason appears to be that researchers and government agencies are viewing performance rating and labelling systems as one of the best methods of moving the

8. *Energy Efficiency Programs for Commercial Buildings: Summary of Discussions*, for Natural Resources Canada, by Ron Robinson, ARC Applied Research Consultants, October 1997, Natural Resources Canada, NG096.

9. Preliminary Survey of the Commercial Buildings Incentive Program, Rich Janecky and Nils Larsson, *Advanced Buildings Newsletter* Number 22, September 1999, Green Building Information Council, Ottawa.

performance benchmarks in the marketplace towards a higher level of performance. There is a growing realization that a major jump in performance levels, at least in market economies, will depend on changes in market demand, and that such change cannot occur until building investors and tenants have access to a relatively simple method that allows them to identify buildings that perform to a higher standard.

The advantages of having a global standard for building performance assessment and labelling cannot be over-emphasized. If meaningful information about performance is to be exchanged between countries, then a uniform definition of performance parameters must be developed, even if the calculation tools providing data on, for example, energy consumption and emissions, vary between countries. Further, the rapid growth of global corporations, and their desire to work to a common standard, give this work a significant commercial importance in the medium term.

Canada is currently leading a process called Green Building Challenge (GBC), a consortium of nineteen countries that are developing and testing a new environmental performance assessment system. The GBC project is an attempt to develop a second-generation assessment system; one that is designed from the outset to reflect the very different priorities, technologies, building traditions and even cultural values that exist in various regions and countries. In order to use the system, national teams must first adjust the values and weightings embedded in the system, thereby assuring results that are relevant to local conditions. The direct output of this process will be primarily at the level of R & D; specifically, a thorough understanding of issues involved in designing such a system, as well as a continuing exchange of ideas on the subject by the best researchers in the field. However, public- and private-sector organisations will be encouraged to use the results to develop a new generation of commercial labelling systems, and this is expected to have positive practical results in the near term for industry applications in Korea, Hong Kong, Canada, Japan and several other countries. Those European countries that are already developing their own systems are using the GBC process to exchange ideas and to improve their own systems, and GBC has already influenced the recent version of BREEAM '98.

The project has consisted of two stages: an initial two-year process, which culminated in the GBC '98 conference, a major international event in Vancouver in October 1998; and a second two-year process of development, the results of were displayed and reviewed at the international Sustainable Buildings 2000 conference in Maastricht, the Netherlands, in October 2000¹⁰.

The assessment framework has been produced in the form of software (GBTool) which facilitates a full description of the building and its performance, and also allows users to carry out the assessments relative to regional benchmarks. Participating national teams test the assessment system on case study buildings in each country. 24 teams will be preparing assessments for the next round of work, culminating in SB2002, to be held in Oslo.

In this next and third phase of work, the responsibility for managing the process will be taken over by a new non-profit organisation, the *International Initiative for a Sustainable Built Environment*, or iiSBE. Canada will continue to support the central management and design functions, but each participating country is now expected to finance its own participation in meetings and for testing the system at home.

Defining Performance

We must now define the type of performance improvements that are required to make buildings more "green". Beyond the obvious issue of energy consumption and GHG emissions, other factors are normally included in a performance framework. The work of IEA Annex 31 and the international Green Building

10. See GBC'98 and GBC2000 pages at<<http://greenbuilding.ca>>.

Challenge (GBC) process provide useful results for this analysis. Most of the information provided in this section derives from the GBC process.

The GBC framework includes criteria for Context factors (not rated), Resource Consumption, Environmental Loadings, Indoor Environmental Quality, Service Quality, Economics and Management. The framework follows an approach used in many other systems; to cover a broad range of performance issues in order to make it more relevant to the industry. Advances in all of these issue areas have also been shown in other assessment systems to be a necessary part of the solution, if they are to be accepted by the industry.

There is a consensus emerging amongst researchers as to the nature and exact definition of the issue areas outlined above. This may lead to the impression that there is also a consensus on the range of criteria that should be included in a working system, which is far from true. Within the GBC, for example, opinions have ranged across the spectrum, from those who would like to see only a core set of green issues included, such as Resource Consumption and Environmental Loadings. The issue area of Indoor Environmental Quality was added relatively quickly to this list, in view of the known importance this issue has within the industry.

The current assessment parameters included in GBC now include the following issues:

- Context Factors (not rated)
- Transportation (emissions from related commuting transport)
- Resource Consumption (non-renewable energy, land, water, materials)
- Environmental Loadings (greenhouse gas emissions, air pollution, ozone depletion, solid waste, liquid waste, effects on adjacent properties)
- Indoor Environmental Quality (air quality, thermal comfort, daylighting, lighting, acoustics,)
- Service Quality (adaptability, maintainability)
- Economics (life-cycle emphasis)
- Management (staff training, tenant performance incentives etc.)

Performance targets and Regional Variation

The previous section has outlined the type of system that may be helpful in increasing the market demand for high-performance buildings. However, such systems need specific performance targets to be meaningful.

The experience of all system developers has clearly shown that the relative importance of performance issues varies greatly from region to region. This is not just a matter of climate and material availability, but also links to issues of building traditions, cultural and sociology. For example, modern office buildings in Europe are often built with narrow floor plates (distance between exterior walls on a typical floor) and with natural ventilation, whereas their North American cousins tend to have very deep floor plates, sealed windows and full mechanical air conditioning. Some of this can be attributed to climate - for example, summertime relative humidity tends to be higher in continental N.A. regions relative to coastal European

ones. However, it also reflects a much stronger preference in Europe for daylighting (which needs narrow floor plates) and for natural ventilation. It also reflects a willingness of office workers in some European regions to willingly tolerate more deviations from a temperature and RH comfort zone. It must also be noted that Europeans are generally willing to spend more on their buildings than are North Americans. This has a major impact on the expectations for building performance that again affects the way that it will be assessed.

To give an example, we could compare two new office buildings, one Canadian and the other Swiss. The annual energy consumption (heating, cooling and electricity) for the Canadian might be 125 kWh/m², while the Swiss building would probably perform better, say 90 or 100 kWh/m². These two different energy consumption figures mask a large number of interesting and relevant issues, with major environmental consequences. A short and partial list of examples includes:

- Strong preferences for natural daylighting leads to a narrower floor plate of the Swiss building and an emphasis on windows, exterior shading and light shelves to reduce glare. Given good lighting controls, this leads in turn to reduced use of electric lighting during the day, which reduces electrical consumption. On the other hand, the deeper floor plate (a more square shape) will give the Canadian building a shape that minimizes the surface area to volume ratio and hence makes it easier to optimize energy performance.
- Strong preferences for natural ventilation in Switzerland leads designers to use natural ventilation approaches, to the extent possible, while the North American tradition in office building design is to mechanical cooling and ventilation. A natural ventilation approach affects indoor air quality and thermal comfort, and workers in the two countries differ in their willingness to tolerate short periods of thermal discomfort.
- There will be differences in environmental impact, due to the fact that the Canadian building probably uses electricity generated by a mix of coal, hydro and nuclear sources, while the Swiss building probably obtains its electricity from generally "green" (e.g. low environmental impact) sources. Material sources will also greatly affect their embodied energy.

Do all the differences outlined above mean that the Canadian designer and builder are not as good as their Swiss counterparts? The answer is that both sides are bound by certain conditions and traditions that they have to work with, and a successful assessment system must allow local users to adjust scores through weightings, so that the different priorities can be respected in the results.

Environmental performance indicators

While regional values and differences are certainly important, the GBC process has shown that a need to make direct comparisons remains. Thus, a series of six "environmental performance indicators" have been added to supplement the relativistic assessments.

Actual and Potential Energy Performance

In the previous sections we have outlined some necessary theory. Reality is quite different, of course, but the theory helps to explain real-world data on building performance and how we can move from there to a more efficient future.

Toronto survey of office buildings

A recent survey of office buildings in Toronto provides some useful real data¹¹. In 1998, an experienced mechanical engineer carried out a survey of about 80 private-sector office buildings in the Toronto area. The buildings have a total area of about 250,000 sq.m., range from 3 to over 50 storeys and range in age from very recent to more than 36 years old. This is, in other words, a fairly good sample of the office building stock in a modern North American city.

The survey covered both energy and water consumption, and related these to hours of occupancy and vacancies. These factors can be significant and the sample showed that vacancy rates averaged 10%, overtime use occurred in 15% of the space and averaged 24% of the normal occupancy hours in that space. Average annual energy consumption (including electricity) was 402 ekWh/m² per year, while electric demand (which has strong cost implications) averaged 74.3 W/m². Water consumption was an average of 1610 L/m² per year. These values mask a high level of variation in results, especially in related supporting uses, such as data processing, restaurant kitchens and retail facilities, which averaged 1884, 1345 and 409 ekWh/m² per year, respectively.

The author of the study, Robert Tamblyn, estimated that average energy consumption could be reduced from 402 to about 280 ekWh/m² per year, from lighting improvements alone.

C-2000 and CBIP performance

The C-2000 and CBIP programs operated by Natural Resources Canada provide information about the potential performance of buildings, e.g. performance estimated before occupancy. Information about the actual performance of these buildings will gradually become available as monitoring studies are completed, but for now they provide a look at modern practice in North America.

From the C-2000 and CBIP Programs, the following data are indicative of what can be done at the design stage:

C-2000 Building Name	Reference MNECB ekWh/m ² per year	Design Performance ekWh/m ² per year
Bentall 8 & 2	348	174
Green on the Grand	182	82
Saskatoon Library	463	301
Dundas Apartments	170	125

11. Tamblyn, R.; *Real Energy Performance Data on Office Buildings in Toronto*; Advanced Buildings Newsletter 21; September 1998; pg. 1-14.

CBIP Building Type	Reference MNECB ekWh/m ² per year	Design Performance ekWh/m ² per year
Health care (4)	427	247
Office (14)	389	252
School (20)	329	216
Other (5)	546	325
All (43)	383	243

It must be remembered that the results cited above are for the potential performance of these buildings, as simulated¹² before occupancy. Our experience with post-occupancy monitoring leads us to believe that the assumptions used in simulation programs and the energy code for office buildings lead to excessively optimistic results, by a factor of about 15% to 20%. Most of this is due to occupancy schedules and electrical loads for equipment that were not anticipated at the time of design.

Despite these qualifications, the results of these programs indicate that office buildings in Toronto or similar locations in Canada can be designed to reach levels of real energy consumption in the range of under 200 ekWh/m² per year under operating conditions, considerably better than the more than 400 ekWh/m² per year that is typical of existing office buildings in the Toronto survey.

Improving the Design Process

The introduction to this paper noted that enabling measures, especially design support tools, could play a useful role in moving the industry towards higher standards of performance.

The design process is important because the initial design of a new or renovated building will largely determine, for better or for worse, the subsequent potential performance of the building over its service life. Building operators and users may degrade performance, but it is difficult for them to markedly improve the performance of a badly-designed building. Research and field experience has also shown that the greatest potential for performance improvement occurs very *early* in the design process. Current efforts are therefore largely focused on integrating the efforts of architects, engineers and others, and on providing guidance, training and support tools during the very early part of the design phase.

Much of the work in this area is focused on technical calculation or simulation software, including tools to simulate energy performance, emissions, air quality and thermal performance. One of the areas of most rapid development is in the development of models to carry out life-cycle assessments (LCA), and there will soon be a series of such tools available to designers. The work of IEA Annex 31 has been important in identifying tools relevant to the energy aspects of building performance assessment systems, and the results of this Annex will soon become available.

There is also a high level of current interest in design tools to assist the effectiveness of the design process itself. Research in this area in Canada goes back 6 years, through the activities of the C-2000

12. Simulations are carried out with EE4, a version of DOE 2.1E with additional libraries and a compliance module. The work is carried out by consultants retained by the client, but files are subsequently checked at NRCan.

demonstration program. The program managers were expecting that projects meeting the demanding performance criteria (including a 50% improvement in energy performance) would have to include a wide range of the latest technologies. In fact, while technologies were certainly up-to-date, all participants agreed that the most significant help in reaching the performance targets were the changes in design process required by the program. These included an integrated design process (architects and engineers working together from the beginning of the concept design stage), the provision of support specialists and the identification of performance targets by the team. These findings are now being formalized in the form of software support tools. One of these is a shortened version of the GBC tool (C2k-A, see Appendix 1) intended for use in concept design stage performance assessment. The tool has been field tested in two projects to date with considerable success.

Canada is, of course, only one of the many countries with an interest in improving the design process. One group with an interest in integrated design is the US-based Bild-IT organisation, which is developing (in close co-operation with the IAI) a series of software tools to support integrated design within the HVAC industry. IEA Task 23 is investigating the relationship between the design process and the adoption of active and passive solar technologies. More than 12 countries are involved in this Task, and existing design protocols are being investigated and a number of case studies documented. One product of the Task is a Multi-Criteria Decision-Making tool (MCDM-23) that is intended (as is C2k-A) for early performance assessments.

More effort is needed to develop support tools for renovation processes, and many researchers are now beginning to focus on this need. A barrier to rapid improvement in this area is that, while one can generalize about certain features of new building design, renovation projects tend to be unique. Nevertheless, there is progress, especially in cases where a significant stock of buildings share similar characteristics, such as post-war European housing, Chinese housing projects, or 1960's Canadian office buildings.

An evident need, from the practitioner's perspective, is to integrate and to simplify tools. This is, of course, at variance with the demand for tools to address an increasingly complex range of issues, but many researchers are now focusing on this problem through, for example, the *ADELIN*E and *Building Design Advisor* platforms. In addition, the work of the *International Association for Interoperability* (IAI) is likely to result in major improvements in the ability of various software tools to exchange data with each other.

Points of Intervention and Relevant Actors

Key points of the normal development process include:

- Planning (of the area in which the building is located);
- Site acquisition;
- Financing;
- Development permit;
- Schematic Design;
- Contract Documentation (drawings and specs);
- Procurement;

- Construction;
- Operation; and
- Demolition.

It is generally accepted that the impact of decisions varies inversely with the time in the process the decision is made, while the direct cost of such decisions vary directly with time. In other words, early decisions are usually cheap and have a major impact on the ultimate performance of the building, while later changes are expensive and have little hope of improving performance.

In spite of this finding (reinforced by C-2000 experience) many policy makers focus their efforts on designers and operators. While it is true that the design process occurs relatively early in the lifespan of a building, it is not early enough to affect some of the basic pre-design decisions. And while building operators can seriously degrade building performance, they cannot improve it beyond the potential aimed for by the designers.

If this argument is accepted, it becomes clear that the very early phases of planning, site acquisition and financing are overlooked as potential points to encourage high performance, and that the schematic design phase is critically important. And underlying all of this is the tax structure that provides subtle incentives and disincentives.

The previous argument does not mean that designers, contractors or operators are unimportant as agents of change in the industry; but that there may be a significant number of other actors who are involved in earlier stages and who should become a focus for activity. These include:

- Investors;
- Real estate brokers;
- Corporate Tenants; and
- Residential purchasers and tenants.

Given the differences that exist between different regions, it is difficult to predict who the key players would be. However, it would not be unreasonable to include key individuals in the following type of organisations as potential allies in green building education efforts:

- Major development companies with an interest in high performance;
- Banks or other form of investor organisations with an interest in real estate;
- Major commercial real estate brokers;
- Major tenant organisations with an interest in high performance;
- Architectural and engineering associations; and
- Architects and engineers with proven interest in high performance.

What's in it for the Private Sector?

Although programs have been developed to provide incentives for the industry to move towards high performance, experience shows that they are far more effective when the client is convinced that there will be a marketing advantage in following this path.

A building that has undergone a design process that results in a high level of energy efficiency is likely to be of higher quality, and will have lower operating and maintenance costs. Capital cost and design time increases are modest¹³, and such buildings have been shown to attract desirable tenants. All these factors are very likely to combine to result in a higher long-term asset value.

For designers, use of the Integrated Design Process offers many engineers to become involved in the early design stage of buildings for the first time; and architects are learning valuable new skills. When this is combined with the incentives available, it is difficult to see any obstacles to widespread participation.

When labelling systems are widely available, more definitive proof of the importance of high performance will be at hand and poorly-performing buildings will hopefully become a relic of the 20th Century.

13. *Incremental Costs in the C-2000 and CBIP Programs*; N. Larsson and J. Clark, March 2000, *Building Research and Information*.

**GERMANY'S NATIONAL CLIMATE PROTECTION PROGRAMME¹ AND THE ROLE OF
THE TRADE UNION FOR BUILDING, AGRICULTURE, FORESTRY AND THE
ENVIRONMENT (IG BAU) WITHIN THIS CONTEXT**

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IG BAU and ICFTU

INTRODUCTION

This contribution tries to illustrate the measures implemented by the Federal Government since 1998 that have made important contributions to the overall decline in CO₂-emissions (chapter 1 – 8) and the role of the unions, especially the Trade Union for Building, Agriculture, Forestry and the Environment (IG BAU) within this process (chapter 9).

AMBITIOUS TARGETS AND EFFECTIVE MEASURES RESOLVED

The “Red/Green” (Social Democratic/Green Party coalition) Federal Government has responded to the major environmental challenge faced by mankind as a result of global climate change with a new climate protection programme, adopted on 18 October 2000 at the proposal of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. The world's leading climate research scientists unanimously agree that the process of global climate change has already begun. The likelihood of storms and flooding, and the risk of shifting vegetation zones, continues to rise as a result of global warming.

In order to be effective, climate protection efforts must be internationally co-ordinated. Solid foundations for an internationally co-ordinated approach are now in place, thanks to the United Nations Framework Convention on Climate Change, which entered into force in 1994, and the Kyoto Protocol adopted in 1997. In this respect, the industrialised nations face a particular challenge, since they are responsible for a high proportion of greenhouse gas emissions and also have access to a wealth of technical and economic opportunities. Against this background, Germany's Federal Government feels that consistent action at a national level is essential.

OBJECTIVES

The Federal Government's targets are extremely ambitious:

1. This presentation of the National Climate Protection Programme is mainly based on the official paper of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety (<http://www.bmu.de>).

- To reduce emissions of carbon dioxide by 25% by 2005 compared with 1990 levels.
- To reduce emissions of the six greenhouse gases cited in the Kyoto Protocol by 21% between 2008 and 2012, within the context of EU burden-sharing. 1990 is the base year for CO₂, CH₄ and N₂O, and 1995 for H-CFC, CFC and SF₆.

Furthermore, for the first time the Federal Government has also set specific targets relating to technology and energy resources:

- A doubling in the proportion of renewable energy sources by 2010 compared with current levels, and a further substantial increase in the proportion of renewable energy sources after 2010.
- The expansion of combined heat and power generation by means of set quotas, aimed at cutting CO₂ emissions by an additional 10 million tonnes by 2005, and by 23 million tonnes by 2010.
- A significant increase in energy productivity over the next few years.

Finally, for the first time, the Federal Government has set reduction targets for individual sectors.

PRESENT SHORTFALLS CREATE A DIFFICULT STARTING POSITION

Although the previous Federal Government set ambitious climate protection targets, it failed to take effective action which would have enabled it to meet these targets.

Forecasts at the time of the change of government in 1998 were based on the assumption that the measures resolved thus far would fall far short of the climate protection targets. The forecast for 2005 anticipated a reduction in CO₂ of just 15 – 17%, suggesting that the measures contained in the previous government's four climate reports were way short of the mark. Not only did it lack the willingness to take effective action; what is more, those measures which were taken were only adopted very sluggishly.

- Impacts of the package of measures adopted prior to the change of government (i.e. between 1990 and 1998): **15 – 17% reduction in CO₂ by 2005 compared with 1990**
- Impacts of the measures adopted by the “Red-Green” (i.e. Social Democratic/Green Party) coalition since taking power (Renewable Energy Act, DM 200 million market launch programme for renewable energy sources, “100,000 roofs” programme to promote solar power, ecological tax reform, introduction of low-sulphur and non-sulphur fuels): **18 – 20% reduction in CO₂ by 2005 compared with 1990**
- Remaining shortfall between now and the year 2005: **5 – 7% reduction in CO₂ by 2005 (equivalent to 50 – 70 million tonnes of CO₂)**
- Breakdown of the shortfall into individual sectors (sector targets):

Private households and buildings: **CO₂ reduction of 18 – 25 million tonnes by 2005 (1.8 – 2.5 percentage points compared with 1990)**

Energy sector and industry: CO₂ reduction of 20 – 25 million tonnes by 2005 (2.0 – 2.5 percentage points compared with 1990)

Transport:

CO₂ reduction of 15 – 20 million tonnes by 2005 (1.5 – 2.0 percentage points compared with 1990)

Should one sector prove incapable of reaching its reduction target, this must be compensated by stepping up the efforts in other sectors.

KEY ASPECTS OF THE NEW CLIMATE PROTECTION PROGRAMME

Between 1990 and 1999, CO₂ emissions were cut by 15.3%, whilst emissions of the six 'Kyoto' gases (CO₂, CH₄, N₂O, SF₆, H-CFC and CFC) were reduced by around 18.5%.

However, emission trends in the individual sectors have shown an asymmetrical pattern over the past decade. Whilst CO₂ emissions in industry showed a dramatic 31% reduction between 1990 and 1998, and the energy sector likewise reported a substantial decrease of 16.1%, emissions of carbon dioxide from private households over the same period increased significantly by 6%, whilst those from traffic were up 11.1%. The traffic sector in particular gives much cause for concern, since emission trends here have shown a continuous upward development since the early Nineties.

If we are to achieve the set climate protection targets, it is essential to bring about a trend reversal in the two aforementioned areas.

MEASURES ADOPTED AND ALREADY EFFECTIVE SINCE THIS GOVERNMENT TOOK POWER

The following measures implemented since 1998 have made important contributions to the overall decline in CO₂ emissions:

- The ecological tax reform, which envisages a gradual increase in energy prices in all segments in order to create incentives for the development and market launch of new technologies, coupled with the rational and economical use of energy.
- The Renewable Energy Act, which promotes the conversion of renewable energy sources into electricity.
- The market launch programme for renewable energy sources, which particularly benefits the use of solar panels, as well as rational energy use.
- The “100,000 roofs” programme, which supports investments in photovoltaic systems.
- The promotion of low-sulphur and non-sulphur fuels also helps to achieve a breakthrough in fuel-efficient, low-emission engine technology.

NEW PACKAGE OF MEASURES CLOSES THE GAP

In order to make up the remaining shortfall in its 25% target (50 – 70 million tonnes of CO₂), the Federal Government, at the suggestion of the Federal Ministry for the Environment, Nature Conservation and Nuclear Safety, has now adopted the following measures. Other measures can be found in the report on “CO₂ reduction” by the inter-ministerial working group of the same name.

EXPANSION OF COMBINED HEAT AND POWER GENERATION

By the end of 2000, the Federal Government will have presented the key points of a quota arrangement aimed at expanding combined heat and power generation. This aims to cut CO₂ emissions by an additional 10 million tonnes by the year 2005, and 23 million tonnes by 2010. The legislative procedure should be complete by mid-2001 at the latest. The energy industry and other parties are currently involved in drafting a concrete concept.

ADOPTION OF THE ENERGY SAVING ORDINANCE

The Energy Saving Ordinance is geared to a so-called primary energy approach – in other words, the losses arising in the chain from energy extraction to energy use (accounting for around two-thirds of primary energy in the case of electricity) will be attributed to the end consumer as far as possible. This will ensure equal competition between fuels. The Energy Saving Ordinance is designed to cut the energy demand of new buildings by around 30% compared with current standards. Furthermore, the Ordinance also envisages compulsory upgrading of existing buildings and extended, more stringent requirements for structural measures. The Ordinance will make a lasting contribution to energy saving in the buildings sector.

SUBSIDY PROGRAMME TO REDUCE CO₂ IN EXISTING BUILDINGS

All the experts unanimously agree that existing buildings offer substantial technical potential for reducing carbon dioxide emissions. Over the next three years, the Federal Government has earmarked additional funds totalling DM 1.2 billion for a “climate protection programme for existing buildings”. This means that low-interest loans to an amount five times as high are made available by the Kreditanstalt für Wiederaufbau (Bank for Reconstruction) in Frankfurt/Main. The “Climate Protection Programme for Existing Buildings” designed to save an additional 5 to 7 million tonnes of CO₂ which is necessary to achieve the climate protection goal of the Federal Government requires annual investments of DM 2 billion until 2005. In order to trigger these investments the Federal Government will make available to the Kreditanstalt für Wiederaufbau 400 million DM for an initial 3 years. The question as to whether this programme will be continued beyond the year 2003 will be dealt with in the context of the discussions of the draft budget for 2004. In addition, the Federal Government requested the Kreditanstalt für Wiederaufbau in Frankfurt/Main to extend the existing CO₂ reduction programme by a minimum of 5 years and, if possible, to increase the current loan volume.

- DECLARATION BY GERMAN INDUSTRY ON CLIMATE PROTECTION
- PACKAGE OF MEASURES FOR THE TRANSPORT SECTOR
- CREATION OF AN ADDITIONAL WORKING PARTY TO THE INTERMINISTERIAL WORKING GROUP ON CO₂ REDUCTION

- VOLUNTARY COMMITMENT BY THE FEDERAL GOVERNMENT
- OTHER GREENHOUSE GASES

Finally, the Federal Government has also adopted additional measures to reduce other greenhouse gases. For example, between 1990 and 2005, measures in the field of wastes from human settlements will lead to a reduction in CH₄ emissions by 15 million tonnes of CO₂ equivalents.

INTERNATIONAL AND EUROPEAN DIMENSIONS

An analysis of current emission trends in the European Union Member States reveals some alarming developments. With the exception of Germany, Luxembourg and the United Kingdom, greenhouse gas emissions in all other Member States show a significant increase. It is therefore vital for policies and measures to be stepped up, both at national and at Community level. Otherwise, there is a danger that the European Union will fail to meet its Kyoto commitment to reduce greenhouse gases by 8% by 2008/2010 compared with 1990/1995 levels. The Federal Government is intensively and very constructively involved in the process introduced by the Commission to develop a European strategy. Based on Germany's experiences since 1990 in the development and implementation of a national climate protection programme, it is contributing actively to the current debate.

The Federal Government is fully aware that even the most ambitious German climate protection policy cannot avert the threat of climate change alone. With this in mind, it calls particularly on those states whose greenhouse gas emissions have risen in recent years to develop and implement a similarly ambitious policy.

National and international climate protection policy cannot be allowed to abruptly end in 2005 or 2012. The Federal Government feels it essential that the obligations for industrialised nations outlined in the Kyoto Protocol for the initial commitment period 2008 - 2012 should be stepped up significantly during subsequent commitment periods, and that as well as industrialised nations, developing countries should likewise undertake to limit their emissions, particularly those who – in absolute terms – already have high emissions or whose emissions are rising sharply. The Federal Government will continue to actively support the developing countries in their climate protection endeavours. Within this context, the Federal Government will review and update its commitments.

TABLE 1: OVERVIEW OF CONTRIBUTIONS TO CO₂ REDUCTION

AREA OF ACTION	REDUCTION CONTRIBUTIONS COVERED BY THE FEDERAL GOVERNMENT'S CLIMATE PROTECTION PROGRAMME, IN MILLION TONNES OF CO₂ BY THE YEAR 2005²	REDUCTION CONTRIBUTIONS COVERED BY THE FEDERAL GOVERNMENT'S NEW CLIMATE PROTECTION PROGRAMME, IN MILLION TONNES OF CO₂ BY THE YEAR 2010
Ecological tax reform	10 million tonnes (reduction contribution as the sum total from all sectors)	20 million tonnes (reduction contribution as the sum total from all sectors)
Buildings (heating/water)	13 – 20 million tonnes	
Private households excluding buildings (electricity etc.)	5 million tonnes	
Industry	15 – 20 million tonnes	
Traffic	15 – 20 million tonnes	
Energy industry	20 million tonnes	
Renewable energy sources	13 – 15 million tonnes	Approximately 20 million tonnes
Waste management	15 million tonnes *	20 million tonnes
Agriculture	Impossible to quantify	
Overall effect with due regard for duplications	90 – 95 million tonnes	
For additional information: sink function of German forests	30 million tonnes	30 million tonnes

Some of these figures refer to CO₂ equivalents on the basis of avoided CH₄ emissions.

²The figures in this column are derived from the reduction effects of measures already adopted (24 – 34 million tonnes) and the additional measures adopted on the basis of this report.

Calculated CO₂ equivalents on the basis of avoided CH₄ emissions

THE OUTLOOK UNTIL 2020: RESULTS OF THE "WITH ADDITIONAL MEASURES SCENARIO"⁴

The “with additional measures scenario”³ takes into account the impacts of the additional measures and mechanisms outlined above for the period 2005 to 2020.

TABLE 2: DEVELOPMENT OF ENERGY-BASED CO₂-EMISSIONS IN THE "WITH ADDITIONAL MEASURES SCENARIO"

<i>SECTORS</i>	<i>INITIAL VALUES</i>		<i>WITH ADDITIONAL MEASURES SCENARIO</i>		
	1990	1995	2005	2010	2020
Industry	199	142	119	112	97
Small consumers	97	68	62	57	46
Households	158	149	113	98	72
Traffic	145	166	180	167	139
Energy conversion	378	327	250	221	177
Total excluding process related emissions and international air traffic	977	852	724	655	531

³ Stein, G. and Stobel, B., Politikszzenarien für den Klimaschutz <Policy scenarios for climate protection>, Volume 1: Szenarien und Maßnahmen zur Minderung von CO₂ Emissionen in Deutschland bis zum Jahre 2005 <Scenarios and measures to reduce CO₂ emissions in Germany by the year 2005>, Study commissioned by the Federal Environment Ministry, Jülich 1997

Stein, G. and Strobel, B., Politikszzenarien für den Klimaschutz <Policy scenarios for climate protection>, Volume 2: Emissionsminderungsmaßnahmen für Treibhausgase, ausgenommen energiebedingtes CO₂ <Emission reduction measures for greenhouse gases with the exception of energy-related CO₂>, Study commissioned by the Federal Ministry for the Environment and Nature Conservation, Jülich 1997

Stein, G. and Strobel, B., Politikszzenarien für den Klimaschutz <Policy scenarios for climate protection>, Volume 3: Methodik-Leitfaden für die Wirkungsabschätzung von Maßnahmen zur Emissionsminderung <Methodology guide for assessing the effects of emission reduction measures>, Study commissioned by the Federal Ministry for the Environment and Nature Conservation, Jülich 1998

Deutsches Institut für Wirtschaftsforschung (DIW), Forschungszentrum Jülich, Fraunhofer-Institut für Systemtechnik und Innovationsforschung (FhG-ISI), Öko-Institut, Politikszzenarien für den Klimaschutz II, Szenarien und Maßnahmen zur Minderung von CO₂-Emissionen in Deutschland bis 2020 <Policy scenarios for climate protection II, Scenarios and measures to reduce CO₂ emissions in Germany by 2020>, Berlin, Jülich, Karlsruhe, June 1999

Wuppertal-Institut, Bewertung eines Ausstiegs aus der Kernenergie aus klimapolitischer Sicht <Evaluation of the phasing out of nuclear power from the point of view of climate policy>, Wuppertal 2000

Deutsches Zentrum für Luft- und Raumfahrt e.V, Institut für technische Thermodynamik, Stuttgart; Wuppertalinstitut für Klima, Umwelt, Energie GmbH, Wuppertal; Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg, Stuttgart;

International Economic Forum Renewable Energies (IWR), Münster and Forum für Zukunftsenergien, Bonn, "Klimaschutz durch Nutzung erneuerbarer Energien" <Climate protection via the use of renewable energy sources>, Bonn, Münster, Stuttgart, Wuppertal 1999

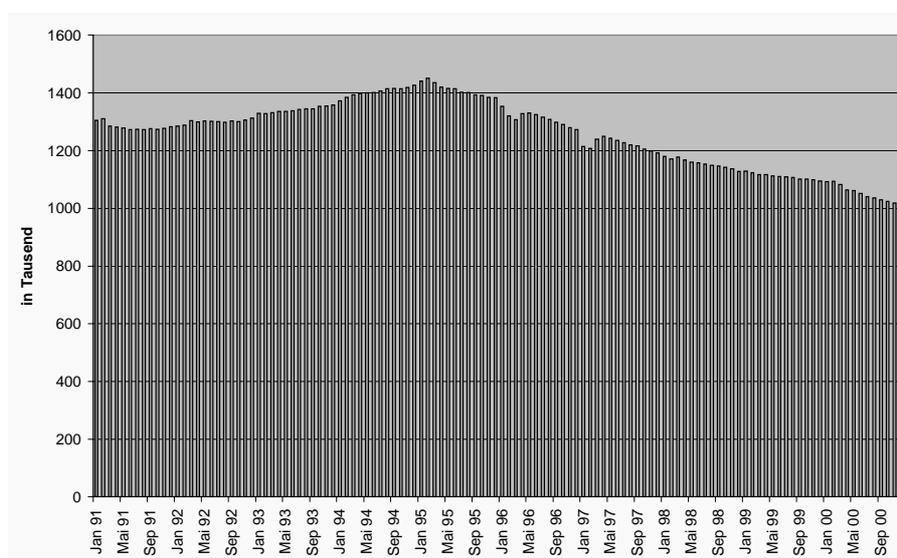
The "with additional measures" scenario predicts an overall reduction in emissions of around 26% (by 2005), 32% (by 2010) and 45% (by 2020) respectively.

TABLE 3: ADDITIONAL CLIMATE PROTECTION POLICIES AND MEASURES IN GERMANY (ONLY CROSS-SECTIONAL MEASURES AND PRIVATE HOUSEHOLDS) (SINCE THE "RED-GREEN COALITION" CAME TO POWER IN AUTUMN 1998)

No.	DESCRIPTION OF MEASURE	REDUCTION OF GREEN-HOUSE GAS EMISSIONS BY 2005 COMPARED WITH 1990 LEVELS	REDUCTION OF GREEN-HOUSE GAS EMISSIONS BY 2010 COMPARED WITH 1990 LEVELS	IMPLEMENTATION DATE
	CROSS-SECTIONAL MEASURES			
1	Ecological tax reform	10 million tonnes CO ₂	20 million tonnes CO ₂	On-going project
2	Voluntary commitment by the Federal Government to reduce CO ₂			
3	DM 100 million per annum(2001–2003) Development and demonstration projects relating to environmentally-friendly energy forms	Impossible to quantify at present		
	PRIVATE HOUSEHOLDS			
4	Energy Saving Ordinance	4 million tonnes		Autumn 2000
5	Improved implementation of the Energy Saving Ordinance by the Länder	Impossible to quantify	Impossible to quantify	From autumn 2000
6	Subsidy programme for energy saving in existing buildings, including the implementation of energy diagnoses	5 – 7 million tonnes		July 2000
7	Development and expansion of eco-subsidies as part of the home ownership promotion scheme			
8	Energy consumption codes for buildings within the context of the Energy Saving Ordinance	Impossible to quantify		
9	EU-wide maximum consumption standards for electricity-intensive household appliances and stand-by mode			
10	Measures directed at the electricity Consumption (particularly stand-by mode) of electrical and electronic appliances in households and offices; voluntary commitments and tighter/extended legislation on energy consumption labelling	5 million tonnes		Mid-2000
11	Promotion of "green electricity"			On-going project
12	Extending the loan programmes offered by Federal Government banks			July 2000
13	Campaign for "Climate protection amongst private households/small consumers"			July 2000
14	Greater market penetration of state-of-the-art household technology, such as calorific boilers, small district heating power stations, fuel cells, connection to district heating supply systems, measurement and control technology, energy-efficient household appliances, communications technology and entertainment electronics			
15	Intensification of research, development and demonstration efforts			
16	Promoting the use of natural gas	3.1 million tonnes CO ₂		On-going project

The Unions within the climate debate

The intense involvement of the unions in the climate debate, especially within the building sector is not astonishing regarding the sector not only as an important economic factor with tremendous environmental impact, but also as a major provider of employment. In the last decade the building sector in Germany



recorded an enormous loss of jobs (Fig. 1).

Fig. 1: The development of work places in the building sector in Germany.

Apart from job-related reasons the unions are aware of their responsibility to foster a more sustainable development in the 21st century. Since the first days of this discussion the unions have tried to support this process in a co-operative manner. After some worries at the beginning the unions are now a recognized partner and an active stakeholder, e.g. in the multi-stakeholder dialogue at the CSD-conferences.

On 20 March 1997 the Economic and Social Committee, acting under Rule 23(3) of its Rules of Procedure, decided to draw up an own-initiative opinion on *Sustainable development in building and housing in Europe*. IG BAU representatives supported actively this process. At its 348th plenary session (meeting of 1st October 1997) the Economic and Social Committee on Sustainable development adopted its final document².

Also one of the most relevant parts of the German National Climate Protection Programme, the renovation of the building stock, is the result of a concerted action under the involvement of the IG BAU. Within the coalition for labour (“Buendnis fuer Arbeit”), a meeting of top leaders of business federations, unions and politicians with the intention to foster a decline of national unemployment, a group under the umbrella of the German chancellor has been installed in 1999. Under the guidance of the IG BAU, this ‘Task force for labour and the environment’ (Fachgruppe fuer Arbeit und Umwelt) smoothed the way for the decisions concluded in the “Subsidy Programme to Reduce CO₂ in Existing Buildings” in the National Climate Protection Programme. On behalf of the IG BAU and Greenpeace the Wuppertal Institute for Climate, Environment and Energy has investigated simultaneously the possible effects on the environment and jobs

2. Available under <http://www.ces.eu.int> (ECS 983-1997).

of extensive renovation of residential buildings to optimise energy savings.³ The starting point was the joint project “Das Plus für Arbeit und Umwelt“, which the industrial union Bauen-Agrar-Umwelt (IG Bau) and Greenpeace intend to initiate in co-operation with the housing industry.

The assumption underlying the survey is that by this initiative and by further necessary measures, above all on the part of the Federal Government, the number of residential buildings to be renovated in terms of energy-saving measures every year can be increased from around 150,000 today to approximately 330,000 a year. In order to achieve this, around DM 15b will have to be invested annually between 1999 and 2020. This sum corresponds to almost three per cent of the total construction volume of the year 1997. Investments to this extent

- will secure and create on a long-term basis approximately 430,000 jobs, 174,000 of these in the finishing trade alone;
- will decrease energy costs through the reduction of the final energy input by 1,111 PJ (50%) and avoid up to 97.5 m t (58%) of carbon dioxide compared with the reference year 1999;
- will also achieve considerable savings of resources (balance of expended and saved material flows), which will reach a scale of around 68 m metric tonnes annually by the year 2020.

This investment plan, which would have to be activated by a support programme among other measures, is facing higher revenues of the state from national insurance and from direct and indirect taxes. At the same time, expenditures for social benefits will decrease because of an improvement in the labour market situation.

3. The report in German is available under <http://www.arbeit-und-umwelt.de>, a summary in English could be ordered by the author.

**POLICY OPTIONS FOR IMPROVING THE EFFICIENCY OF EXISTING BUILDINGS:
EXPERIENCE TO DATE IN THE UNITED STATES**

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Abstract

Existing buildings offer tremendous opportunities for cost-effective energy efficiency improvements. Designing policy instruments that take advantage of these opportunities, however, presents a unique set of challenges to policy makers. Given the energy savings potential in this market, it is important for energy experts, policy makers, and program managers to pursue policies that can capture the energy and emissions savings possible. This paper describes several policy approaches and summarizes how these instruments have been used in the United States.

Introduction

Commercial and residential buildings constructed prior to 2000 will account for approximately two-thirds of U.S. buildings sector energy consumption in 2020. Improving the efficiency of these properties is essential to reducing building sector carbon emissions. Fortunately, numerous studies have demonstrated the tremendous opportunities for cost-effective retrofits of existing homes and commercial buildings. Retrofit technologies can reduce building energy consumption by 30 percent or more while improving air quality, occupant comfort, and worker productivity.

Despite the benefits associated with building retrofits, building owners are often reluctant to invest in energy efficiency improvements for several reasons. They may be unwilling to invest scarce capital in efficiency improvements when they are uncertain about the savings that will result from specific measures, how long they will own the building, and whether the efficiency improvements will affect the resale value of their property. In lease properties, landlords and tenants face split incentives that discourage investment in efficiency improvements. Incentives to encourage building upgrades or regulations to require certain levels of energy performance can play an important role in capturing the savings opportunities.

Yet, energy experts, policy makers, and program managers in cities, states, and utilities throughout the U.S. have focused their efforts on policies to improve the efficiency of new construction rather than the existing building stock. The lack of attention to existing buildings policies largely stems from: (1) the higher costs and greater difficulty of implementing efficiency measures into buildings after design and construction; and (2) the larger number of players involved in efforts to improve the existing building

stock. Despite these difficulties, several policy approaches have been used to reduce the barriers to energy efficiency investments and to bolster the efficiency of existing buildings.

This paper surveys some of the policy instruments that have been used by federal, state, and municipal governments in the U.S. Policies and programs targeting existing single- and multi-family homes will be discussed first, followed by information on the more limited range of policies directed toward existing commercial buildings.

Policies to Promote Efficiency Improvements in Existing Homes

In this section, several policy approaches for increasing homeowners' investment in energy efficiency are presented. The success of a given policy or the appropriate mix of policies depends largely on a range of political and financial considerations as well as the culture of the particular community. Jurisdictions must explore various policy options and consider which approaches or combination of approaches might be used to their best advantage. Much of this section draws from an earlier paper (Suozzo, Wang and Thorne 1997) which provides a comprehensive review and detailed case studies of numerous programs.

Financing Programs for Efficiency Improvements

Financing programs, typically in the form of zero- and low-interest loans for energy efficiency improvements, are offered by several states, utilities, and other organisations throughout the U.S. These programs are receiving renewed attention as utility rebate programs for energy efficiency continue to decline. Loans programs provide homeowners with access to capital at below-market rates and often with generous repayment periods. The level of financing may vary substantially, from small loans for basic weatherization to larger financing for major capital projects. To encourage larger-scale efficiency improvement, some states and utilities may offer additional buy-down of interest rates on larger loans. Programs which simplify the loan process by providing consumers with same-day credit approval, auditor and contractor referrals, contractor bidding services, and loan application processing are most successful in generating consumer interest.

Loan programs are relatively low cost to administer, generally costing less than direct subsidy programs. The program administrator (whether a state or local agency, utility, or other organisation) partners with banks or other lenders for loan origination and servicing, and with energy auditors and contractors for program marketing. In many cases, greater efficiency investments are made because the loan programs effectively leverage private sector funds. Since many private lending institutions are reluctant to process small loans (e.g., \$2,000 or less), public agencies and specialty lenders such as Energy Finance Solutions¹ with a mission to encourage efficiency investments, may finance these smaller accounts internally.

Monitoring and evaluation are important to the success of any loan program. These components provide a form of quality control to ensure that funds are not misused and that contractors are providing quality services. In addition, program tracking provides useful insights into program participation and effectiveness and helps identify opportunities for improvement in program marketing and administration. A review of loan programs in the U.S. suggests several approaches for reducing barriers to customer participation and improving loan effectiveness (Suozzo, Wang and Thorne 1997). Key recommendations include:

1. Energy Finance Solutions is an authorized loan underwriter and originator in the Fannie Mae Residential Energy Efficiency Improvement Loan Program. EFS works directly with state and local programs, utilities, and contractors to provide low-cost, unsecured loans for efficiency improvements. For more information, visit www.energyfinancesolutions.com or www.weccusa.org.

- Make it simple to participate by offering consumers hassle-free access to information and applications and ensuring that program staff and customer service representatives are knowledgeable.
- Provide customers with choice through flexible loan amounts and terms.
- Build in quality control mechanisms, such as consumer education, contractor training, inspections, and preferred contractor programs to ensure that only cost-effective measures are implemented and to encourage quality workmanship.
- Partner with experts to deliver loan services and market the program. Lending institutions, contractors, energy auditors, and realtors have expertise that can be invaluable to program administrators and participating homeowners.

Tax Incentives for Efficiency Improvements

Tax incentives, if properly structured, can stimulate investment in efficiency improvements and new technologies by making retrofits more affordable for homeowners. Previous experience in the U.S., however, demonstrates the difficulties in crafting effective tax credit programs for existing homes. From 1977 to 1985, the federal government offered tax credits for a number of standard residential energy efficiency measures. Studies suggest that the tax credit program suffered from high levels of free ridership and had relatively little impact on consumer behavior due to the small size of the credit, lack of promotion, and administrative burdens (Geller 1999). In the end, the tax credit was used largely to subsidize a number of incremental efficiency improvements that probably would have been made in the absence of the credit.

New proposals for tax credits, currently under consideration in the U.S. Congress, address some of these problems, but a number of concerns persist. For example, the legislation provides for tax credits for improvements that are “certified to improve the annual energy performance by at least 30%” and, therefore, may avoid subsidizing small incremental improvements that would be undertaken without the tax incentive. However, it is unclear what end uses are included, what the base period for comparison will be, and what types of certification will qualify (e.g., modeling or actual energy use). Addressing these concerns would require substantial investments of time and resources, making the tax credit program burdensome to administer.

Residential Energy Conservation Ordinances and Weatherization Standards

A number of states and municipalities in the U.S. have enacted residential energy conservation ordinances (RECOs) as a means for improving the efficiency of existing single- and multi-family homes. RECOs require homeowners and landlords to implement specific, low-cost efficiency measures at the time property is sold or substantially renovated. In many cases, these ordinances have a particular focus on multi-family housing units and rental properties. RECOs are designed to bring the existing housing stock up to a minimum standard of efficiency, which is generally much less stringent than that prescribed by codes for new construction. When properly designed, enforced, and supported, RECOs provide benefits to individual residents as well as the community at large. For example, RECOs guarantee improvements in the efficiency of the existing housing stock (estimated energy savings up to 15%), provide residents and renters with a minimum level of home comfort and reduced energy bills, cost relatively little to administer, and maintain local jobs by supplying regular work for energy auditors, contractors, and others.

When establishing a RECO, the given community selects the appropriate energy retrofits for their area. Typical measures include attic insulation, water heater blankets and pipe wraps, duct sealing and insulation, and weatherstripping and caulking for windows, doors, and cracks. Local climate conditions determine the level of insulation required and whether water conservation measures are included. In many cases, cost ceilings set a limit on the cost of compliance either at a pre-determined dollar amount (e.g., \$1,000) or as a percentage (usually 0.75% to 1%) of the selling price or cost of renovation. The onus for compliance may be put on the seller or the buyer, although in some cases the ordinance allows the parties to negotiate compliance as part of the sale. Enforcement varies, but at a minimum requires inspection to verify compliance and issuance of a certificate of compliance. Additional enforcement mechanisms include required proof of compliance before the deed is recorded; regular re-certification by an energy inspector every few years; and, in the most sophisticated systems, tracking mechanisms that follow the process by issuing follow-up reminders to responsible parties, and prosecution for non-compliance.

Most RECOs were established in the 1980s as a response to the energy crisis of the late 1970s. An exception is the Burlington, Vermont ordinance adopted in 1997. Given the political climate and the preponderance of low energy prices during the late 1980s and 1990s, it has been much more difficult to overcome opposition to additional requirements, such as RECOs. Indeed, some communities fail to garner the full benefits of their programs due to lax enforcement, while other communities that had RECOs in place (or in development) have seen their ordinances abandoned in the face of political pressure. Some cities and states have incorporated RECO-type standards into housing code in the form of minimum weatherization standards. Weatherization standards tend to be more politically feasible because of their emphasis on rental property, particularly low-income housing. In the Pacific Northwest, the states have established a low-income weatherization standard to address the decline in utility-funded efficiency programs. Utilities are required to invest a small percentage of their revenues (0.4%) in low-income weatherization.

RECOs and related weatherization standards promote easy to implement efficiency measures in a large portion of the community's existing housing. Although the focus is on measures with relatively small efficiency improvements, effective enforcement of requirements can garner substantial overall energy savings with relatively low implementation costs. Case studies highlight some of the important components in successful design and implementation of RECOs (Suozzo, Wang and Thorne 1997).

- Engage interested parties in all phases of RECO development and implementation to get the political support and co-operation necessary for RECO approval and successful implementation and enforcement.
- Develop effective compliance tracking and enforcement mechanisms to ensure that the energy savings and other benefits of the RECO are realized.
- Collect and disseminate program impacts data to stakeholders to maintain support for the program, illustrate program benefits to the community, highlight potential refinements to the program, and allow other communities to learn from the experience.

Home Energy Ratings and Energy Mortgages

Home energy rating systems (HERS) provide homeowners with information about the energy efficiency of their home and recommendations for cost-effective efficiency improvements. Customers in the market for a home can use HERS to identify homes that have been rated as energy-efficient. Energy mortgages (EMs) work in concert with home energy ratings to provide consumers with mortgage incentives. Specifically,

energy improvement mortgages (EIMs) provide financing for upgrading an existing home, and energy-efficient mortgages (EEMs) help consumers purchase energy-efficient homes by “stretching” the debt-to-equity ratio above maximum loan limits for qualifying energy-efficient homes. EMs operate under the assumption that homeowners with energy-efficient homes will pay lower monthly energy bills and, therefore, have additional resources to service slightly higher mortgage payments.

The development of accurate home energy rating systems played an important role in securing mortgage industry support for EMs by addressing lenders’ reluctance to make loans unless it could be shown that energy improvements actually resulted in savings on borrowers’ monthly energy costs. Although home energy rating systems were used in the 1980s, voluntary national guidelines for uniform HERS were first established as a provision of the Energy Policy Act of 1992 (EPACT). Today, virtually all HERS programs rely on this performance-based scaled rating system. Homes are rated on a scale of 1 to 100 according to their efficiency; the rating is then translated into an easy-to-use 1 to 5 star rating, with 5 stars being the most efficient. Several software programs have been developed to assist raters in estimating the home energy rating based on the results of a series of diagnostic tests.² HERS has also been adopted as the basis for the ENERGY STAR Homes label. Homes with a HERS score of 86 or higher, qualify for the ENERGY STAR.

The EPACT also provided for a five-state pilot test of EMs using Federal loan instruments.³ The pilot programs were funded from FY1993 to FY1999; two additional state pilots joined the program in 1996. The U.S. Department of Housing and Urban Development selected the pilot states; the U.S. Department of Energy worked with HERS providers in each state to set up the programs and develop a system for evaluating each program’s success.⁴ HERS activity in the pilot states has spurred the expansion of HERS to 47 states and the District of Columbia, with several national lenders now offering EMs. Evaluation and case studies from the pilot programs and other active states offer a wealth of information about program participation and the effectiveness of HERS and EIMs (e.g., energy and cost savings), and suggest recommendations for improving program performance (Judkoff and Farhar, 2000; Suozzo, Wang and Thorne, 1997).

As a result of these efforts, the infrastructure for the HERS and EMs industries has evolved to accommodate the delivery of these products to consumers. The following activities will be important to further the impact of these programs, enhance stakeholder support, and build consumer demand.

- Ensure the accuracy of ratings to build lender confidence and maintain support for the program. Continued testing and evaluation of HERS techniques and accreditation of energy raters can ensure that the mortgage industry’s investments in residential energy efficiency are economically viable.
- Redouble marketing efforts to increase consumer awareness of HERS and EMs. Providing stakeholders, including raters, lenders, and realtors, with information and tools to help them understand the benefits of these programs to consumers and the best ways to sell them can go a long way toward increasing demand for HERS and EMs and garnering the energy savings from their implementation.

2. Leading software programs include Rateview, REMRate, and EZ Rater. More information on rating guidelines and these products can be found at www.natresnet.org.

3. The U.S. Federal Housing Administration and Department of Veterans Affairs offer federally-insured loans for housing.

4. For detailed information and an evaluation of the pilot programs, see Farhar 2000 and Judkoff and Farhar 2000.

- Simplify the process for all parties involved and partner with other organisations to offer a diverse array of services. Experience in Vermont and other pilot states has shown that consumers, lenders, real estate agents, and contractors are more likely to participate if the program provides a user-friendly process with one-stop shopping that keeps the number of contacts they must make to a minimum (Faesy 2000; Judkoff and Farhar 2000). Diversification of services can also help the program administrator keep administrative costs down and provide additional revenue to support the program if state and federal funding is reduced.
- Improve data collection and tracking to aid in program evaluation, help isolate problems and identify opportunities for improvement, and generate further stakeholder support for HERS and EMs. Essential data include: 1) the number and percentages of ratings used for financing and other incentives; 2) the recommended energy improvements that are actually implemented; and 3) the market resale value of energy-efficient homes versus homes that are not.
- Better link HERS and EMs. States and localities have made progress in linking HERS programs with lending programs offering EMs, however more needs to be done. Several large private lenders are emerging as leaders in the field by offering EMs in their portfolio of loan products. The U.S. EPA is also actively developing energy mortgage and financing programs to support the HERS-based ENERGY STAR Homes program.

Policies to Promote Efficiency Improvements in Existing Commercial Buildings

Efforts to develop policies to improve efficiency in existing commercial buildings have been much more limited than those in the residential sector. A number of state and local governments have established revolving loan funds and requirements for efficiency improvements in existing public buildings, but few have expanded their efforts to target the competitive commercial real estate market. A few policy and program approaches, however, have been explored and increasing attention is being directed toward commercial properties. This section briefly summarizes the major areas of activity to date.

Commercial Energy Conservation Ordinances

Based on the success of their residential energy conservation ordinances, two communities - San Francisco, California and Berkeley, California - have enacted the nation's only commercial energy conservation ordinances (CECOs). Like RECOs, the commercial ordinances seek to improve the efficiency of commercial buildings by requiring implementation of specific, cost-effective efficiency measures at the time of title transfer, when significant building renovations are made (i.e., more than \$50,000) or when additions increase a building's conditioned space by more than 10%.

CECOs require an initial inspection to identify areas of non-compliance and prescribe efficiency measures required under the ordinance. Once the prescribed measures are completed, a follow-up inspection must be performed to verify that the required measures were implemented and a certificate of compliance is recorded with the city. Typical measures cover building insulation and HVAC, hot water, and lighting systems, and, where applicable, commercial refrigeration, motor driven equipment, pools and spas. If properly implemented, the City of San Francisco anticipated that CECO could produce energy savings of 10% to 30% in affected properties (Egel, Cook and Knox 1990). The CECOs incorporate limits to the expenditures required for compliance at a set amount (e.g., \$150,000) or percentage of the property's sale price or assessed value, or percentage of construction costs for renovations and additions. In addition,

measures that do not meet a set test for cost-effectiveness (e.g. a simple payback of 4 years or less) may be exempted.

The complexity of commercial building systems and the wide range of commercial building sizes and types are reflected in the complicated requirements of CECOs. Just as commercial building codes are more complicated than residential codes, CECOs are more complicated to implement and enforce than RECOs. As a result, CECOs have been much more difficult to administer and enforce. Compliance has been substantially lower than RECO compliance, particularly in the larger city of San Francisco. Higher administrative costs, limited public awareness, and insufficient staff have further hindered the ordinances' effectiveness. While CECOs have the potential to contribute significant energy savings and emissions reductions, additional efforts to simplify the ordinances and streamline their administration and enforcement are needed.

Energy Performance Benchmarking and the ENERGY STAR Buildings Label

In 1998, the U.S. Environmental Protection Agency (EPA) and the U.S. Department of Energy (DOE) launched the ENERGY STAR Building label to recognize the most energy-efficient commercial buildings in the country and to motivate building owners and operators to improve the energy performance of their facilities. The voluntary program uses a performance-based rating system that allows building owners to compare the performance of their buildings to similar buildings in their region.

Using the Internet-based benchmarking tool, the building owner inputs data on building location, square footage, operating hours, occupant density, plug load power density, and the monthly energy consumption over a twelve-month period. The benchmarking tool compares this information to data from a national database and provides the user with a rating for their building and a Statement of Energy Performance with detailed information on building energy use, energy costs, atmospheric emissions, and performance targets. Buildings scoring 75 or above on the 0 to 100 scale are eligible for the ENERGY STAR label. Specialised benchmarking tools are available for office buildings and schools; tools for the retail and hospitality industries are under development.

EPA has developed a set of tools to help building owners identify and schedule efficiency improvements and analyze the financial implications of various upgrade options. In addition, financial analysis software is available at no charge to help commercial real estate asset managers in determining how the efficiency upgrades can increase operating income, reduce vacancy rates, increase appraisal value, and otherwise affect their bottom line. These and other tools have been used to demonstrate that energy efficiency is a sound business investment. The program has been particularly well received among commercial property owners and property management firms. States and utilities are exploring ways to incorporate the ENERGY STAR Buildings label and other program elements into the financing and technical assistance programs they offer.

Conclusions

The retrofit policy instruments examined in this report differ in cost and ease of administration, the level of energy savings they can garner and their ability to motivate building owners to make efficiency investments. Table 1 summarizes the major advantages and disadvantages of each approach. While there are drawbacks to each approach, combining elements of the programs can result in greater energy savings by enhancing participation and reinforcing the message with consumers and commercial building owners. Recommendations for combining the approaches presented into potentially more effective programs include:

- Adopt HERS as the basis for RECO compliance inspections or in lieu of loan program audit requirements. Tying more products to HERS would build the ratings' credibility and further support development of HERS infrastructure. In addition, HERS values for ratings throughout the community could be used to establish baseline energy use, determine program requirements such as minimum standards and eligible conservation measures, or to indicate RECO compliance. Basing RECOs and loan programs on a nationally recognized rating system may also make program development and administration easier.
- Expand the use of home energy ratings and building performance benchmarks and link with other energy efficiency financing. Rating and benchmarking systems provide a simplified, nationally recognized system for identifying cost-effective efficiency improvements and energy-efficient buildings. These systems make it easier for all parties to identify sound efficiency investments. Financing can help building owners, particularly homeowners and small business owners, make efficiency improvements that would otherwise remain unaffordable.
- Offer financing to assist the parties subject to energy conservation ordinances or weatherization standards by linking with programs that sponsor low-interest loans and energy mortgages. This could encourage compliance and make the necessary efficiency improvements more affordable.

Combining program elements promotes partnerships between a broad range of stakeholders, increasing awareness and understanding of the many benefits of energy efficiency. Combined programs also offer administrators the potential for greater cost sharing among programs. Together, these approaches can demonstrate that cost-effective energy efficiency improvements are achievable, save energy, and benefit the communities in which they are implemented.

Table 1: Major Advantages and Disadvantages of Policy Approaches

Approach	Advantages	Disadvantages
Residential financing programs	Cost-effective for larger jurisdictions; May offer greatest energy savings; Leverage greater private funds	Expensive to start and market; Requires extensive marketing and consumer education
Residential energy conservation ordinances	Low-cost to implement locally; Mandatory compliance	Small per household savings; Politically difficult to enact or enforce
Residential tax credits	Stimulate investment in large energy savings	Difficult to design effectively; Free rider issues; Expensive to administer
Home energy ratings and energy mortgages	Uniform approach for national or regional program; Leverage greater private funds; Large energy savings potential	High start-up costs for program infrastructure and marketing; Cost-effectiveness uncertain; May not be self-sustaining
Commercial energy conservation ordinances	Potential energy savings significant; Mandatory compliance	Difficult to design and enforce; Politically challenging
Commercial energy performance benchmarking and labelling	Uniform approach for national program; Easy for users and simple to implement; Recognition encourages participation	Requires extensive education and marketing; Energy savings uncertain

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References

Egel, K., J. Cook and B. Knox. 1990. "Mandating Energy Efficient Commercial Buildings: San Francisco's Commercial Energy Conservation Ordinance." *Proceedings of the 1990 ACEEE Summer Study in Buildings*. pp. 7.43-7.50. Washington, D.C.: American Council for an Energy-Efficient Economy (ACEEE).

Faesy, R. 2000. "Understanding and Overcoming the Energy Mortgage Barrier: Financing Energy Improvements in Existing Homes." *Proceedings from the 2000 ACEEE Summer Study on Energy Efficiency in Buildings*. pp. 2.91-2.102. Washington, D.C.: ACEEE.

Farhar, B. 2000. *Pilot States Program Report, Home Energy Rating Systems and Energy-Efficiency Mortgages*. NREL/TP-550-27722. April. Golden, Colo.: National Renewable Energy Laboratory.

Geller, H. 1999. *Tax Incentives for Innovative Energy-Efficient Technologies*. Washington, D.C.:ACEEE.

Judkoff, R. and B. Farhar. 2000. "Lessons Learned: Five Years of Home Energy Rating Systems (HERS) and Energy-Efficient Mortgages (EEMs) in the Pilot States." *Proceedings of the 2000 ACEEE Summer Study on Energy Efficiency in Buildings*. pp.9.201-9.214. Washington, D.C.: ACEEE.

Suozzo, M., K. Wang, and J. Thorne. 1997. *Policy Options for Improving Existing Housing Efficiency*. Washington, D.C.:ACEEE.

CONSTRUCTION AND DEMOLITION POLICY IN THE NETHERLANDS

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Construction and demolition waste

Construction and demolition (C&D-) waste constitutes a large part of the waste produced in the Netherlands. C&D waste is defined as waste that is produced by building or demolition activities. Soil is not considered as C&D waste, except when the soil is attached to e.g. stony materials.

In the Netherlands nowadays more than 90% of the C&D waste is recycled. In this presentation some instruments are proposed, that are a prerequisite for an effective waste minimisation policy. There are many other instruments used to reach this goal. This paper does not address them all.

For an effective use of these instruments it is important to focus on the “End of the chain” of C&D waste. What is defined in this paper as the “end of the chain”?

1. Land filling of disposed materials
2. Use of stony materials as road construction material
3. Use of stony materials as substitute for gravel and sand in concrete constructions
4. Use of other materials for recycling (e.g. metals, wood, plastics)

Experiences in the Netherlands

In recent years the cheapest option for disposing of waste was landfill. Most producers of waste tend to search for the cheapest option. Environmentally better solutions were not considered because of this “natural” incentive. The Netherlands has therefore developed instruments to dissuade waste generators from using landfill as the easiest solution instead of other instruments.

How to prevent landfill?

Generally spoken, there are three ways to prevent landfill:

1. Ban on landfill
2. Taxes on landfill

3. Environmental regulation for building materials (road construction)

1. Ban on landfill

For the ban on landfill a distinction has been made between a ban on dumping in landfill sites and a ban on dumping outside landfill sites.

In landfill sites

Since 1997 a ban on recyclable and combustible components of C&D waste has been in effect. It is however allowed to dump non-recyclable or non-combustible components in landfills.

Outside landfill sites

There is a general ban on dumping waste outside landfill sites. This ban is also applicable to C&D waste.

Some experience has now been acquired in the use of the ban for landfill sites. One of the major concerns of the ban is how to distinguish between recyclable or combustible components and residues. Especially when mixed waste is received, it is hard to determine whether it is legal to accept the transport for landfill or not. In the 1999 revision of the ban, a distinction has been made by well-defined components. A method is also given to make the distinction. However, this method is rather time-consuming.

In the Netherlands a new problem has arisen. Because of the economic growth which has resulted in much more waste (incl. C&D waste), and because of the ban on landfill for different categories of waste, there is not enough capacity to incinerate the combustible part. Consequently, nowadays some combustible C&D waste is still accepted for landfill.

2. Taxes on landfill

The tax on landfill is part of the “greening the taxes”, which is a general policy in the Netherlands. The aim of this policy is to achieve a shift from “taxes on income” to “taxes on activities with a negative environmental impact”. This policy includes taxes on the use of long cycled energy fuels, drinking water and on landfill. A tax on the use of primary building materials like sand and gravel is also under discussion.

The tax on landfill was introduced in 1996. At that time, for combustible waste like household waste and high caloric sorted wastes, the tax was set at about 70 Euro per ton. For non-combustible waste the tax was about 13 Euro per ton. Nowadays the regular tariff for landfill tax on combustible waste is about 110-120 Euro per ton, and on non-combustible waste about 70 Euro. The tariff of the tax on combustible waste is now at the same level or higher than that for incineration of waste.

The distinction between low and high tariff is based on the *mass/volume rate*. This is based on the assumption that waste with a low mass is suitable for combustion and need not be dumped on a landfill. Only waste producers that can prove that the waste has a mass/volume rate of less than 1100 kg/m^3 are taxed by the low tariff. If one can't prove it, the high tariff has to be paid.

In the Dutch situation this is a system that is rather simple and not very sensitive to fraud.

3. Environmental regulation for building materials (Building materials decree)

The third policy instrument used which is particularly important for the stony parts of C&D waste is the environmental protection of soil. Although dumping outside landfills is banned, it is not always very clear

if stony materials are used as a construction material or are simply dumped. In other words: Is this real road construction material or is it simply a case of a “pseudo-recycling” in order to easily get rid of the waste?

The Building Materials Decree makes no distinction between primary and secondary building materials. All materials should meet limit values for emission (leaching) and composition. Also there should be a certificate which ensures that the material is used properly. The decree also includes an obligation to take back the materials after use.

Future challenges in the Netherlands

Because of the increasing amount of waste, studies have been made in order to find new ways to prevent waste. C&D waste appeared to be one of the waste streams which has some potential for waste prevention. Many instruments used to simulate waste prevention are almost similar to instruments used for separation of waste. The Dutch government is now considering new instruments for the prevention and recycling of C&D waste.

One of the instruments is an obligation to sort C&D waste at the building and demolition sites. This legislation should be national. On a local level, municipalities already have the ability to impose sorting on the demolition site, but this results in differences between municipalities. The obligation to separate can be an effective stimulation to recycle more components and to prevent pollution of already recycled materials.

Some producers of building materials have already implemented their own take-back systems. These take-back systems could be made more effective if there were an obligation to separate the waste components which can be taken back.

U.S. EPA CONSTRUCTION & DEMOLITION DEBRIS PROGRAM - A CASE STUDY FOR THE OECD

by Ken Sandler

US Environmental Protection Agency

I. Background and Goals of Program

Among the many duties of the U.S. Environmental Protection Agency (EPA) is to reduce threats to human health and the environment associated with the generation and management of solid waste. EPA's Office of Solid Waste (OSW) is charged with this mission, which includes regulating hazardous industrial waste, creating standards for the proper management of landfills and combustion facilities, and fostering increased reduction, reuse and recycling of waste in safe and cost-effective ways.

Over the last decade, EPA and state and local governments have tackled many significant waste challenges, such as the development of comprehensive "cradle-to-grave" hazardous waste regulations and municipal waste landfill and incinerator standards. As one sign of progress, the United States municipal solid waste recycling rate has increased from about 16% in 1990 to approximately 28% in 1998 (the latest year for which final data is available). As a result, greater attention is now being paid to previously neglected waste issues, including that of construction and demolition (C&D) debris.

C&D debris is broadly defined as including three types of waste:

- waste from the construction, renovation and demolition of buildings;
- waste from the construction, renovation and demolition of infrastructural elements such as roads and bridges; and
- waste from the clearing of undeveloped land in preparation for construction.

To date, EPA work on C&D has been overwhelmingly focused on the first type of C&D, while the other two types of C&D have not been a significant focus of the EPA or of other Federal agencies.¹

1. EPA is not aware of any work that has been done in the Federal government on the issue of land-clearing wastes. However, two agencies that have touched on the issue of waste from infrastructure projects are the U.S. Geological Survey <<http://www.usgs.gov>>, which has conducted several studies on the recycling of road-building materials, and the Federal Highway Administration, which is funding the Recycled Materials Research Center at the University of New Hampshire <<http://www.rmrc.unh.edu>>, where numerous research projects on the scientific properties of recycled road-building materials are underway, and a conference on the topic is scheduled for November 13-15, 2001.

EPA's involvement with the issues of building-related C&D debris reduction, recovery and management began in the early 1990s as these issues began to receive heightened attention from solid waste journals and state and local solid waste officials. New associations were formed at this time: the Construction Materials Recycling Association, representing C&D debris recyclers, the Used Building Materials Association, representing building material reuse stores, and the Reuse Development Organisation, representing various reuse organisations, including those involved with building materials reuse.

In general, the environmental challenges of C&D debris relate to its large volume and related resource conservation issues, rather than to acute hazards it may present to human health or to the environment. While there are real hazards associated with the construction, renovation and demolition of buildings - including asbestos, lead painted materials, solvents, paints, coatings, lacquers, etc. - the most hazardous of these materials most frequently appear to be screened out of the C&D waste stream and channelled into the hazardous or municipal solid waste (MSW) streams. Therefore, the waste that ends up in the country's approximately 1,800 C&D landfills are generally believed to present less potential hazard than the waste found in hazardous waste or MSW landfills.

The enormous volumes of C&D waste generated and disposed every year present three related types of environmental challenges:

- The need to dispose of these wastes, and the environmental problems associated with their landfilling or combustion;
- The huge amount of resources used in construction, and the environmental problems associated with that resource extraction, manufacturing, transport, etc.; and
- Impacts on global climate change associated with both the "upstream" (pre-usage) and "downstream" (post-usage) phases of construction materials.

Waste disposal and combustion are often controversial issues in the U.S., due to public fears about pollution being discharged from these facilities. EPA responded to these concerns in 1991, when it promulgated municipal solid waste landfill criteria, designed to more tightly regulate the design and operation of MSW landfills.

While these regulations and trends have affected the C&D debris management industry, which is believed to dispose a significant quantity of C&D debris in MSW landfills, the majority of C&D landfills are much less closely regulated. The only EPA regulation directly affecting C&D landfills is a 1996 rule requiring that C&D landfills either set up a system to ensure that even minute amounts of hazardous waste are screened out, or else meet certain minimum landfill standards (e.g., including siting restrictions and groundwater monitoring).² The lack of any other national C&D regulations (other than relatively broad standards applicable to all landfills) leaves state and local governments free to impose their own regulations if they so choose. Those states and localities that do so generally apply less stringent rules than are applied to other categories of waste. As a result, C&D debris is believed to account for more cases of illegal dumping and unpermitted waste facilities than other categories of solid waste.

The environmental impacts at the upstream, resource input stage of construction are arguably much more significant. The U.S. Geological Survey has estimated, using "materials flow" methodology, that construction materials account for 60% of non-food, non-fuel raw materials consumption in the U.S.³ In addition to the impacts of these resources being depleted, their extraction and processing exact a

2. For more information, see the Conditionally Exempt Small Quantity Generators Rule.

3. See *Materials Flow and Sustainability*, a USGS factsheet, at <http://greenwood.cr.usgs.gov/pub/fact-sheets/fs-0068-98/fs-0068-98.pdf>.

considerable cost on the environment, whether in the form of forest ecosystems being damaged by tree harvesting, large amounts of land being disrupted due to mining, or the various forms of air and water pollution and solid waste produced through the manufacture and transport of building products.

Finally, the environmental impacts of C&D at both the upstream and downstream stages are believed to contribute significantly to the emission of greenhouse gases contributing to global climate change. First, at the upstream stage, the enormous amount of wood used in U.S. building construction contributes to the reduction of the “carbon sinks” represented by forests. Second, also at the upstream stage, the large amounts of fossil fuels used in the manufacture and transport of building materials adds to carbon dioxide emissions. Third, the landfilling of organic materials such as wood leads to the production of methane, a greenhouse gas over 20 times more potent than carbon dioxide.

In response to these varied concerns, EPA has, since 1994, developed a C&D debris management program focused on characterizing the C&D universe, researching and demonstrating best practices for C&D reduction and recovery, fostering markets for construction materials and other recycled materials that can be incorporated into building products, disseminating this information to key players in the industry and working with these players to implement more resource-efficient practices. EPA has taken this approach, as opposed to a more regulatory course, due to its limited statutory mandate and funding in this area, the challenge of the large amounts of material and huge number of actors involved, and the potential economic promise of increased recovery of these materials. In accordance with these factors, and EPA’s traditional approach to solid waste reduction, the two primary goals of EPA’s C&D debris management program are:

- To advance the reduction, reuse and recycling of C&D debris, and
- To stimulate recycling markets by promoting increased purchasing of recycled building materials.

- ***Outline of EPA’s C&D Program***

EPA’s C&D program to date has included the following elements

- characterizing C&D,
- researching and demonstrating best practices for C&D reduction and recovery,
- fostering markets for construction materials and other recycled materials that can be incorporated into building products,
- disseminating this information to key players in the industry and working with these players to implement more resource-efficient practices.

Each of these elements is covered below.

A. Characterizing C&D

In June 1998, EPA published *Characterization of Building-Related Construction and Demolition Debris in the United States*. This was the first comprehensive effort to assess the size, composition and management of the building-related portion of C&D debris in the U.S. This study multiplied data on numbers of construction, renovation and demolition projects in the U.S. (e.g., Census Bureau statistics on yearly construction) with data on estimated waste generation per-square-foot of building (from various

waste assessment studies at building construction, renovation and demolition sites), to come up with nationwide C&D debris generation estimates.

The report estimated an annual generation rate of 136 million tons per year of building-related C&D debris in the U.S. Of this total, 43% was assumed to come from residential sources and 57% from non-residential sources. Also, 8% was estimated to come from building construction, 44% from renovation and 48% from demolition.

The report identified approximately 1900 C&D landfills in the U.S., and cited estimates of between 1800 and 3500 recycling facilities nationwide. The report admitted a lack of good data on percentages of C&D recycled, and therefore estimated only ranges of 20-30% recycling, 35-45% disposal in C&D landfills and 30-40% disposal in MSW landfills, incinerators, and unpermitted sites.

Presently, EPA does not have plans for further characterization activities, except for some background work to determine the climate change impacts of C&D debris generation and management.

B. C&D Recovery Research & Development

In 1994, EPA initiated research and development activities through grants with the National Association of Home Builders Research Center (NAHB RC). This research focused primarily on residential building, in accordance with the association's area of expertise and interest. The research covered residential construction, remodeling and "deconstruction," the practice of disassembling buildings for reuse and recycling of their components.

- **Home construction:** This project produced *Residential Construction Waste Management: A Builder's Field Guide*, a step-by-step guide for builders on home construction waste management and recovery. The guide educated builders on how to use less wood in the framing process, implement recycling on the homebuilding site, estimate costs and savings and experiment with new techniques where appropriate. Among these new techniques, EPA funded research on the grinding of unpainted, untreated wood and drywall waste on site for use as soil amendments.
- **Home remodeling:** This project also produced a Remodeler's Field Guide. It was similar in many ways to the Builder's Field Guide, except that it referred to some of the types of waste more commonly produced through remodeling and noted the greater opportunities for reuse often available with remodeling waste. There were also detailed brochures produced on opportunities for recycling two types of waste commonly produced from remodeling: carpeting and asphalt roofing shingles.
- **Building deconstruction:** EPA's Office of Policy and Economic Innovation led significant efforts to bring Federal agencies, local officials and non-profit organisations together to conduct R&D on the feasibility and cost-effectiveness of the selective disassembly of buildings that otherwise would have been demolished. EPA funded a comprehensive case study of the deconstruction of a two-story public housing building that detailed all costs, income, barriers and benefits, and determined that deconstruction can be "cost-competitive" with demolition.

These research and development projects have opened up new opportunities for reducing residential C&D debris throughout the lifecycle of a building.

C. Market Development

An essential part of EPA's strategy to reduce waste in the United States is to foster the creation of stable, lucrative end-markets for products made from recyclable materials. Recycled building products are an important element of EPA's recycling market development programs.

One of the oldest of EPA's market development programs is the Comprehensive Procurement Guidelines, which sets standards for recycled content products that Federal government agencies are mandated to purchase. EPA provides extensive information about these products, to educate and assist the purchaser, available on the web at <www.epa.gov/cpg>. Although aimed at Federal agencies, these guidelines are also used by state and local governments and private organisations seeking reliable standards for the purchase of recycled products.

Among the categories covered are recycled-content construction products. In the current guidelines, this category includes carpeting, cement and concrete, nine types of insulation, paint, floor tiles and patio blocks, fiberboard and paperboard, and bathroom dividers. C&D debris can also serve as a feedstock for recycled products in other categories, such as landscaping products.

Another EPA market development program is Jobs Through Recycling, which from 1994-1999 provided grants, primarily to state governments, for programs to support the development of recycling industries. A number of these grants related to the recycling of C&D debris, for example, a grant to the Florida Center for Solid and Hazardous Waste Management and the University of Florida Center for Construction and the Environment led to the development of a deconstruction assessment tool, to help determine whether a building is worth deconstructing.

A third EPA program that includes market development in its mission is the WasteWise program, which educates its over 1000 business, government and non-profit partners on how to reduce waste, recycle and buy recycled products, and recognizes them for successes in these undertakings. In Fall 2001, this program will launch an initiative to challenge its partners to recycle more C&D debris and buy recycled building products.

In general, the enormous amount of material used in building products presents excellent opportunities for the use of recycled C&D debris and other secondary materials in construction. The challenge comes in marketing these materials, ensuring their quality and convincing builders and homebuyers to use them.

D. Information Dissemination and Implementation

Information from all of the projects outlined above has been disseminated to audiences with the power to change how C&D debris is generated and managed. The publications produced in partnership with the NAHB RC (section I.B.1 above) have been distributed to approximately 30,000 members of the building community, in addition to being available over the Internet.

Beyond information dissemination, EPA has begun to develop partnerships with members of the building industries and the "green building" movement, to promote the implementation of C&D debris reduction practices. In 1999 and 2000, EPA cosponsored a Green Building Conference aimed at educating mainstream homebuilders about green building practices; also in 2000, EPA developed *A Guide to Developing Green Builder Programs*, a comprehensive manual to help localities develop their own voluntary green building programs, based on the experiences of the first six local voluntary programs then identified. EPA is also participating in the U.S. Green Building Council's project to develop a rating system for green homes, called Leadership in Energy and Environmental Design (LEED)-Residential.

Furthermore, EPA has initiated efforts to improve networking and co-ordination among the many diverse Federal programs involved in different aspects of green building.

For the next phase of its program, EPA is developing a strategy designed to target promising partners to implement more C&D recovery projects in their organisations. This will include: the military, with efforts to increase the deconstruction of closing bases; large public and private organisations that are partners of EPA's WasteWise program, as part of their overall commitment to reduce waste and buy recycled products; and other key audiences. EPA hopes in this way to continue extending the reach of this program and making its impacts felt out in the field.

III. Evaluation

To date, EPA's C&D Debris Program always has been a small program with modest funding. There has never been more than the equivalent of one full-time staff person dedicated to this program, and cumulative expenditures on grants and contract in support of this program from 1994-2001 have equaled approximately \$1.5 million, or an average of over \$186,000 per year.⁴

The C&D program generally has not conflicted with other environmental goals and programs, perhaps partly because it has not yet completely delved into the detailed issues involved with implementing C&D reduction and recovery programs across the U.S. However, as the EPA moves more into implementation issues, there are potential conflicts. For example, it is important to handle deconstructed building materials containing lead-based paint in an environmentally protective manner⁵; however, if hazardous waste rules are too restrictive on the lead issue, deconstruction could become cost-prohibitive. EPA will have to manoeuvre around this type of issue carefully in order to meet its goals to reduce hazards and to conserve resources and reduce the emissions of greenhouse gases.

Due to the modest size of EPA's C&D program and limited funding available for program evaluation, it has been difficult to judge its overall impact. However, following are a number of ways in which EPA has estimated or detected some impacts of this program.

First, working with the National Association of Home Builders Research Center (NAHB RC) allowed EPA to target its home construction, remodeling and demolition projects directly at the approximately 200,000 builder base of that association, and judging by the numbers of publications distributed to this audience - perhaps as many as 30,000, including materials freely available for downloading from the Internet - it is believed that this information is having some impact in the field.

Second, at the conclusion of the two grants to NAHB RC in 1999, the grantee completed final reports that attempted to assess the results of these grants. As a way to project environmental impacts of the first Green Builder Conference, surveys were distributed to all of the nearly 400 attendees asking what environmentally-friendly changes they might make to their building practices as a result of their attendance. Assuming that the builders who responded to the survey each build 23 average-sized homes a year and apply the techniques they mentioned to all of the homes they build, the grantee projected the impacts of the conference at 1,357,712 kilowatt hours of electricity and 7671 MMBtu saved, 7792 tons of materials reduced or recycled and 4,537,026 gallons of water saved.

4. Note: these figures do not take into account some of the market development activities outlined in II.C. above, as these activities were part of other EPA programs.

5. Lead was banned from use in paint as of 1978; therefore, lead-based paint is only an issue for buildings built before that time.

The report also estimated impacts of EPA's publication *A Guide to Developing Green Builder Programs*. Assuming only 10 localities used the guide to develop their own green builder programs, the report projected impacts of 11,799,173 kilowatt hours of electricity and 97,008 MMBtu saved, 42,432 tons of materials reduced or recycled and 24,866,393 gallons of water saved annually.

Since that time, a green building newsletter recently identified a total of over 20 local programs now existing or under development.⁶ One of the most successful new programs, Atlanta's Built Green was modeled on the guide and received technical assistance in its development through the EPA C&D program.

Third, the information dissemination and networking related to the deconstruction project appears to have contributed to growing movement on this issue among other Federal agencies, including the Department of Defense, where the planned deconstruction of military bases slated for closing is increasing, and the Department of Housing and Urban Development, which conducted an extensive report on the feasibility of deconstruction, based on a study of four urban areas around the country. The Federal government's main administrative agency, the General Services Administration, is also becoming increasingly involved in C&D debris issues, e.g., by giving "Demolition Derby" awards to government facilities employing effective and innovative C&D reduction and recycling techniques.

Overall, EPA's C&D program is believed to have made an impact at least commensurate with the resources dedicated to it. The greater attention, information, and activity on these issues as a direct result of this program is also surely having additional indirect, "spin-off" results as more organisations learn about, experiment with and adopt C&D debris reduction and recovery programs and techniques. EPA has helped put this issue "on the map;" now, EPA is focusing on the challenge of turning the increasing awareness of C&D problems and opportunities into action to further reduce the enormous quantities of C&D debris generated across the U.S.

6. Yost, Peter, "Green Building on the Move," Environmental Building News, Volume 10, Number 2, February 2001, p.5.

INCENTIVE FOR INDUSTRIAL ECOLOGY IN BUILDING SECTORS

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INTRODUCTION

As OECD report identifies, OECD Member countries are now trying to establish policy framework to improve resource efficiency in building related economic activities (OECD 2000). So far, most of measures involved in the frameworks emphasizes on promoting recycling of construction & demolition waste. In another word, most of measures currently being undertaken aim to reduce the quantity of final disposal of construction & demolition waste including inappropriate and/or illegal disposal, by focusing on downstream of building process.

However, for fundamental improvement of resource efficiency, there is a need to increase cyclic use of resources within building related sectors by focusing on upper stream of building process. In this context, design of buildings and their elemental components is a key activity, because it defines supply chain and potential 'inverse' supply chain of building related products. It is expected to introduce the concepts of 'DFX (design for X; X is environment, remanufacturing, disassembly etc.)' and 'zero-emission' in building products' design.

Though mandatory policy measures based on the idea of EPR (Extended Producers' Responsibility) might promote the introduction of these concepts to some extent, there is a need to establish more holistic approach. The idea of industrial ecology of building related sectors emerges where the sectors have their own autonomous motivation to introduce the concept of DFX and zero emission.

This brief note discusses possible policies to give incentive to promote industrial ecology in building related sectors. The key question of this note is how could we make DXF/zero emission oriented design profitable for building related sectors.

1. INDUSTRIAL ECOLOGY AS ENGINE FOR BETTER RESOURCE EFFICIENCY

Graedel and Allenby who created the term of industrial ecology stated in their book as follows (Graedel et. al 1995);

Industrial ecology is the means by which humanity can deliberately and rationally approach and maintain a desirable carrying capacity, given continued economic, cultural, and technological evolution. The concept requires that an industrial system be viewed not in isolation of surrounding systems, but in concert with them. It is a system view in which one seeks to optimize the total material cycle from virgin material, to finished material, to component, to product, to

obsolete product, and to ultimate disposal. Factors to be optimized include resource, energy, and capital.

Journal of Industrial Ecology explains what is industrial ecology as follows (<http://mitpress.mit.edu/journals/JIEC/jie-call.html#whatis>);

Industrial ecology is a rapidly growing field that systematically examines local, regional and global materials and energy uses and flows in products, processes, industrial sectors and economies. It focuses on the potential role of industry in reducing environmental burdens throughout the product life cycle from the extraction of raw materials, to the production of goods, to the use of those goods and to the management of the resulting wastes. Industrial ecology is ecological in that it (1) places human activity - industry in the very broadest sense - in the larger context of the biophysical environment from which we obtain resources and into which we place our wastes, and (2) looks to the natural world for models of highly efficient use of resources, energy and by-products. By selectively applying these models, the environmental performance of industry can be improved.

Industrial ecology is, in a sense, a systematic and integrated approach to upgrade environmental performance of industry with planned, gradual and cost-effective methods. If sectors successfully achieve to gain industrial ecology, the sectors could be ‘autonomous engine’ to promote resource efficiency of industry.

2. PRODUCT PROVIDER VS. SERVICE PROVIDER

2.1 Service Provider - New Business model

Most of building sectors take the business model termed as ‘product provider’; The nature of product provider embodies the barriers to accept industrial ecology, because the amount of revenue of product providers get their revenue by provision of building and/or building elements as final goods. The price of final goods is based on the quantity of resource input listed in the bill of quantities. Consequently, decrease of provision of products directly connects to the decrease of revenue of sectors.

As Fig.1 illustrates the difference between product supplier and service provider, ‘service provider’ is an alternative business model that could promote industrial ecology in building related sectors. Service providers get their revenue by providing ‘services’ that generate convenience, comfort, security and various benefits embodied with function and performance of buildings. For service provider, building is a device of services. Prices of supplied services are correlated with the quantity and the quality of services, regardless with resource input to product.

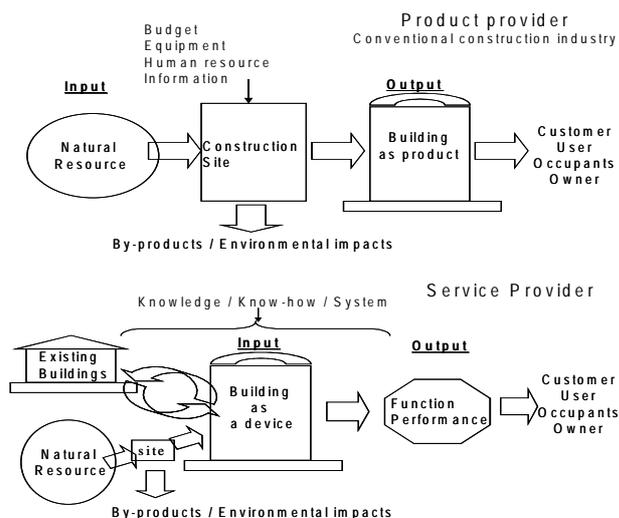


Fig.1 Product provider & Service Provider

For instance, contractors as product provider are responsible for realization of school buildings defined in the contract document. Contrarily,

service providers are responsible to the capacity and the quality of educational services created through educational facilities.

2.2 Potential benefit of service provider

Service providers have motivation to save the cost for service. The most effective saving is using existing building as a device of service with reasonable refurbishment and/or conversion. Thus, the transition from product provider to service provider generates incentive for fundamental improvement of resource productivity in construction.

Fig. 2 shows the difference in resource efficiency between a set of product providers' activities and that of service providers'. Industrial innovation undergoing in developed countries accelerate the transformation of requirements to built environment, while it is believed that construction sectors are responsible for some 40 % of material use in the globe. If construction sectors should keep the conventional business model as product accelerated transformation of requirements would generate the increase material use more than 40 %.

Contrarily, for service providers, new emergence of demand tends to promote use of buildings as devices for supplying. Thus, increase of demand by rapid transformation of requirements does not the increase of the amount of new extraction of resources. Therefore, it can expected that the transition of construction from product provider to service provider great improvement in resource efficiency to built environment in global scale.

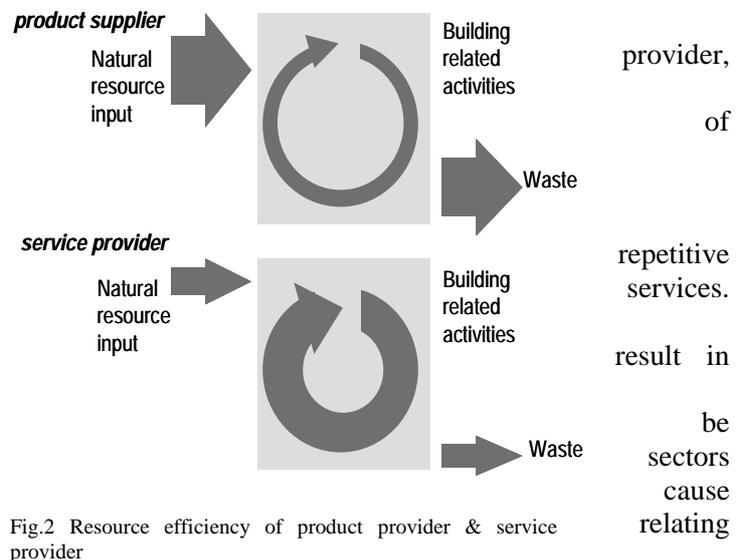


Fig.2 Resource efficiency of product provider & service provider

Thus, the nature of service provider represents the idea of industrial ecology in building related sectors.

Traditional construction procurement to product providers has created number of 'bad' precedents where poor services are offered to users of building in the enclosure of architectural masterpiece, because of weak integration between operational arrangement and architectural composition of building. Service providing business is expected to make break through for the integration based on user' satisfaction. It causes a fundamental change in the relationship between producer and consumer.

2.3 Possible seeds for service providing business

– Leasing of building components

Leasing and/or rental of off-site building components are typical providing business models. Fig. 3 illustrates comparison of material of conversional way of product and that of leasing of building components. For Leasing firm, there the benefit of recycled use of elements. Thus, leasing business embodies the incentive to establish loop of material flow that is termed 'inverse supply chain'.

Users can enjoy benefits because suppliers assure the quality of embodied with functions and performance of components for duration of contract. Though there is on future expense for maintenance and repair, it be beneficial for leasing firm because of potential to increase business opportunities. As Fig. 4 illustrates, the leasing model incentive to fabricate exchangeable and durable components, which contributes to better resource productivity.

– Open building approach

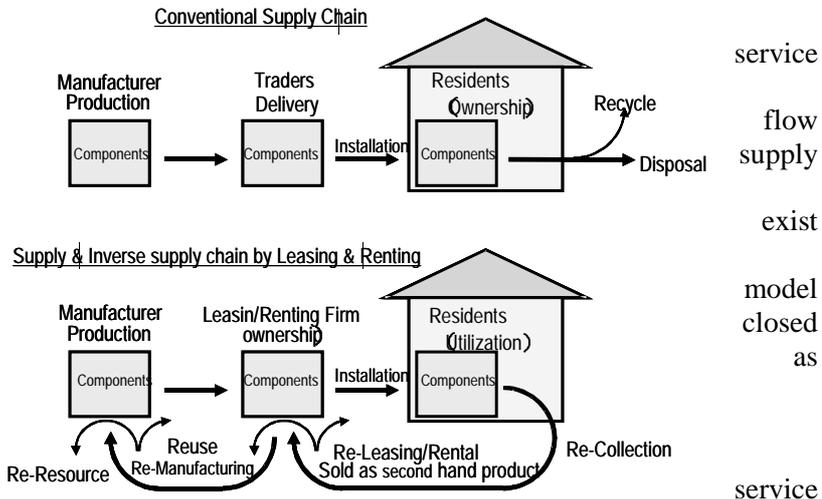


Fig. 3 □ Diagram of material flow of conventional supply chain and Supply & Inverse supply chain by leasing business model

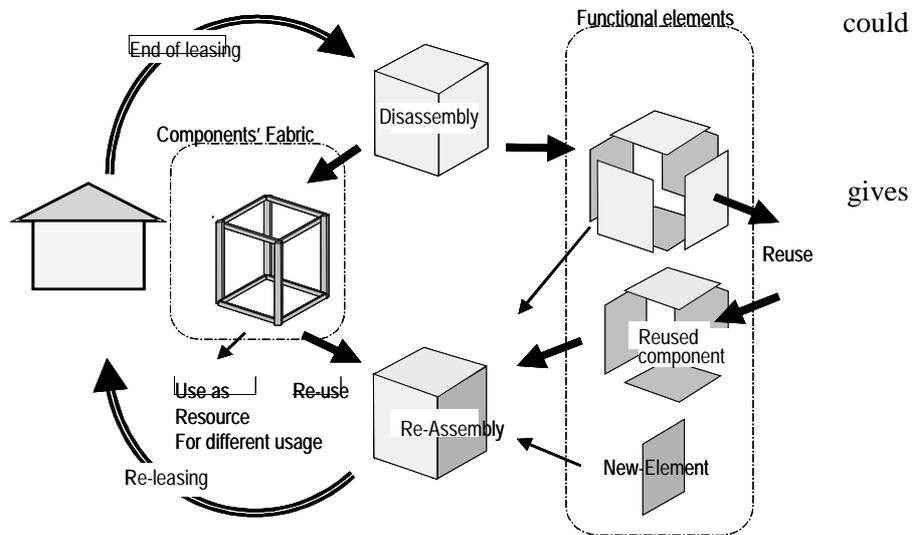


Fig. 4 □ Diagram of re-assembling of leased module components

Works to existing buildings are seeds of various service providing business models. Owners and users of building have explicit/tacit need of tailor-made of building over its life cycle, respecting on ever changing requirements in turbulent socio-economical and technological environment. Open building approach is the methodology of continual customization where, organizationally and physically, built environments are subdivided into several independent levels; urban tissue, support and infil.(Habraken,1998).

3. INCENTIVE FOR SERVICE PROVIDER

Government policies have significant role to encourage industrial ecology by transforming of building related sectors from service provider to product provider.

Procurement policies by governments

First, government needs to give impact on cultural change of building related sectors by following possible measures;

1. Change of governmental procurement policy from product basis valuation to service valuation basis.
2. Governments are largest client to building related industry. Thus, the change of procurement policy give considerable impact on culture of industry and promote that serviceability of building has economic value in market place. The policy includes the encouragement of leasing procurement rather than purchasing procurement.

Encouragement of developing agreed valuation method of 'services'

For exchange of 'services' in market place, there is a need of agreed method of quantifying service for monetary term basis valuation. Governments are expected to take initiative to develop the agreed method as the largest client.

Establishment of contractual status of SLA (service level agreement)

Procurement of service valuation basis requires the established way of contract based on SLA (service level agreement). Governments are expected to take initiative to develop standard format of SLA basis contract.

Financing system

In some country like in Japan, investment to building by banking facilities and financial institutions are based on mortgage to fix property. For promote 'de-materialization' in investment to building, following measures are required.

Mortgage system to service provision.

The right of receiving service defined in the SLA based contract need to have legal status as mortgage in order to promote investment on service based business model.

Insurance system to mitigate risk in service providing business

There are number of risks relating to service providing business. There is a need to create insurance system to mitigate risk embodied with service providing business model.

Intervention to competition in market place

Governments are expected to take following measures to generate competition based on resource efficiency;

Resource efficiency rating and/or audit system

Governments are expected to take initiative to rating and/or audit system on resource efficiency of specific business model by third parties.

Provision of advantage to resource efficient business model

Resource efficient business model could be encouraged by provision of benefit in taxation, charge and/or subsidies by public sectors.

Promotion of R&D

There exist number of technological barriers to support the system illustrated in Fig.4. Realization of 'DFX' concept could be the breakthrough. Governments are expected to encourage and/or take initiative to R&D for 'DFX' based building products.

In addition to the measures above, policies to give heavy charge to final disposal also give incentive to building related sectors' transformation to service providers.

Policies to establish 'Inverse supply chain'

As diagram of Fig.4 illustrates, service providing business model needs to reduce cost for resource acquisition and disposal. It is essential to establish inverse supply chain between different sectors by creating inter- and inner industrial networks where 'waste for some sectors' could be the resource for the other sector. For establishment of these kinds of 'inverse supply chain', governments are expected to take following actions;

Scenario wring of material use balance in regional scale

There is difficulty for single private sectors to have macro scale prospect of waste generation and potential demand to 'waste'. Government and/or agencies that have non-profit status are expected to review macro balancing of material flows to provide information on regional material flow, that is essential for single industrial sector to seek for partners to receive 'waste' as resource.

Provision of benefit for receiver of waste

Quite often, price of virgin resources are cheaper than resource from 'waste'. To construct 'inverse supply chain' by use of 'waste' originated resource, there is a need to prepare benefit to receiver of waste in terms of taxation and charges by public sectors.

IT-based forum

Web page based forum could enlarge the possibility that one sector can find good partner in terms of 'inverse supply chain' network. Governments are expected to take initiative to set up these kinds of It-based forum (Cyber space marketplace)

Mitigation of barriers for logistics

Mass balancing of demand and supply of 'waste' does not assure partnership between tow sectors, because quite often there exit barriers in logistics of 'waste' from generating site to the other site where 'waste' is required. Government need to construct infrastructure, such as re-collection and distribution center, to mitigate barriers in logistics.

CONCLUDING COMMENTS

In OECD Member countries, in a sense, the quantity of existing building stock already exceeds the upper limit of carrying capacity. It is apparent that the need to extend more floor space will be decreased though there exist incremental need to customize existing building stock to meet with ever transforming need in rapidly changing IT economy. In this context, conserving of conventional business model of building related sectors as product provider have a risk to disastrous impacts on natural capital that are necessary for sustainable development. The transformation of building sectors to service provider is essential to avoid the destructive consequences. It is expected that this brief note would generate various initiative to create new business model where building sectors could generate profit with high degree of resource efficiency.

REFERENCES

- Bon, R. & Yashiro, T., Some new evidence of old trends : Japanese construction 1960-1990, Construction Management & Economics, E & FN SPON, vol.14, PP319-323, 1996.
- Giarini, O and W R Stahl, The Limits to Certainty: Facing Risks in the New Service Economy, Dordrecht, Kluwer Academic, 1993.
- Graedel, T.E. et. al, Industrial Ecology, Prentice Hall, 1995.
- Groak, The idea of building, E&FN Spon 1992.
- Habraken N. J. et.al., The Structure of the Ordinary : Form and Control in the Built Environment, MIT Press, 1998.
- Hawken, P. et.al., Natural Capitalism: Creating the next industrial evolution, Little, Brown and Company, 2000.
- Lifset R., Moving from products to services, Journal of Industrial Ecology, pp1-2, vol.4 no.1, 2000, MIT Press.
- OECD, SUSTAINABLE CONSTRUCTION, Policy Design and Evaluation for Sustainable Buildings,2000.

Ryan C., Dematerializing consumption through service substitution in a design challenge, pp3-9, vol.4 no.1, 2000, MIT Press.

Tomiyaama, T., Housing in post mass production age, Housing Forum. Housing Research Foundation, pp28-pp31, vol.51, 1999 (in Japanese).

Weizsacker, E. et. al Factor Four: Doubling wealth, halving resource use, Earthscan, 1998.

RESOURCE EFFICIENCY IN CONSTRUCTION

by Gilli **HOBBS**

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The construction industry has a huge contribution to make to our quality of life. Construction, building materials and associated professional services together account for about 10% of the UK's Gross Domestic Product and provide employment for around 1.5 million people.

The construction industry can contribute to sustainable development by:

- Being more profitable
- Delivering buildings and structures that provide greater satisfaction, well-being and value to customers and users
- Respecting and treating its stakeholders more fairly
- Enhancing and better protecting the natural environment
- Minimising its impact on the consumption of energy (especially carbon-based energy) and natural resources.

(DETR 2000: Building a better quality of life: A strategy for more sustainable construction)

The construction industry uses around six tonnes of material/person per year in the UK. Most of this material resource is held within the building and civil engineering stock until demolition or refurbishment.

Demolition

There has been significant progress in the field of re-utilising demolition products and materials through reclamation and recycling. The demolition industry is very effective at segregating materials with a reuse or recycling market. The landfill tax in the UK has also improved the profitability of reclamation and recycling. Demand for these materials will dictate the levels of recovery where a least cost demolition is required. Where the client is prepared to pay a higher rate for faster site clearance then the levels of recovery will typically decrease.

It has been demonstrated on a number of occasions that over 95% of waste arising from a demolition can be recycled or reclaimed. BRE was involved in one such case study in a client and research capacity.

Demolition of building 16 (1995) – BRE, Watford, UK

The requirement to maximise reuse and recycling was incorporated into the specifications for the demolition contract. All those tendering for the contract were asked to price the job according to scenarios of minimal recovery and maximum recovery. The appointed contractor demonstrated the greatest potential to recycle at the least cost.

A pre-demolition audit identified further materials reclamation and recycling. Where economically viable the contractor carried out additional recovery activities.

The resultant recovery rate of 96% (by volume) was commendable but not especially difficult to attain.

It is apparent that a major element of demolition is to dispose of waste materials at the lowest cost and/or highest revenue. If given sufficient time most contractors will recover in excess of 80% of demolition products. Variables that can affect this general principle include:

- Location of markets compared to final disposal. Haulage of heavy and bulky materials is expensive. Lower value materials will be landfilled rather than travel long distances.
- Investment in demolition equipment. If a contractor has invested heavily in equipment to facilitate rapid demolition then a high throughput of sites is required to recoup the cost. This will reduce the time spent on site and the recovery of smaller volume materials.
- Large amount of contamination or contaminated materials.

Deconstruction

It is estimated that each year 3.3 million tonnes of architectural & ornamental components are salvaged, 24 million tonnes of aggregates are recycled, and an unknown quantity of steel and timber is recycled back into production (1). There are still large volumes of potentially reusable components that are currently landfilled and lost to the system only to be replaced with similar components.

Ultimately, each building should be designed to take into consideration the refurbishment and demolition that will occur at some point. Often the components used in buildings are highly durable and are replaced or disposed of before their predicted lifespan expires. The ideal scenario would be for materials and products to be reused in a construction application.

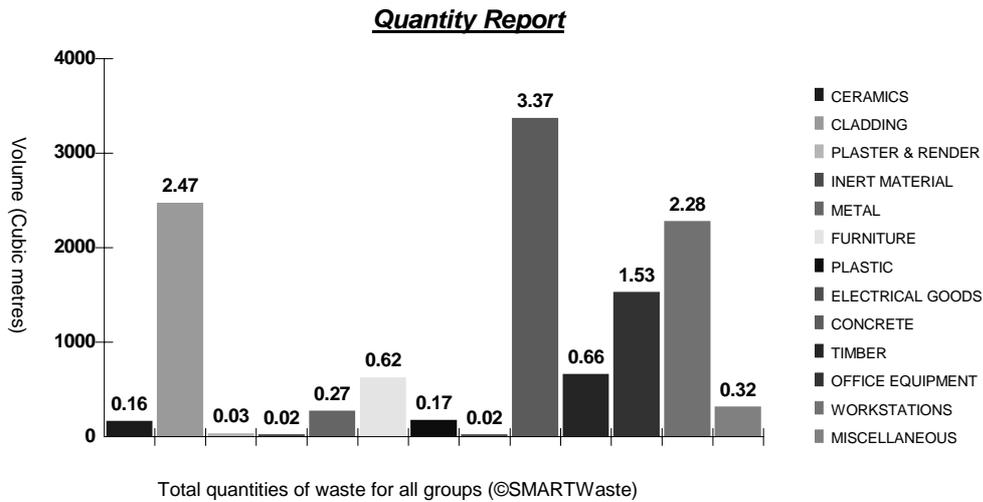
DETR has sponsored BRE to promote further waste reduction and reuse by way of deconstruction. A fundamental part of this study is to undertake pre-demolition and pre-refurbishment audits using the BRE SMARTWaste tool, and to use these results to set targets for reuse and recycling.

To date four projects have been audited but more are required. The following table and graphs are extracts from three of those audits to demonstrate the level of detail gathered. This information should be made available at the tender stage so that a contractor is able to set targets and monitor their success. It also allows clients and main contractor to judge demolition contracts with best value in mind. This is particularly valuable to Local Authorities.

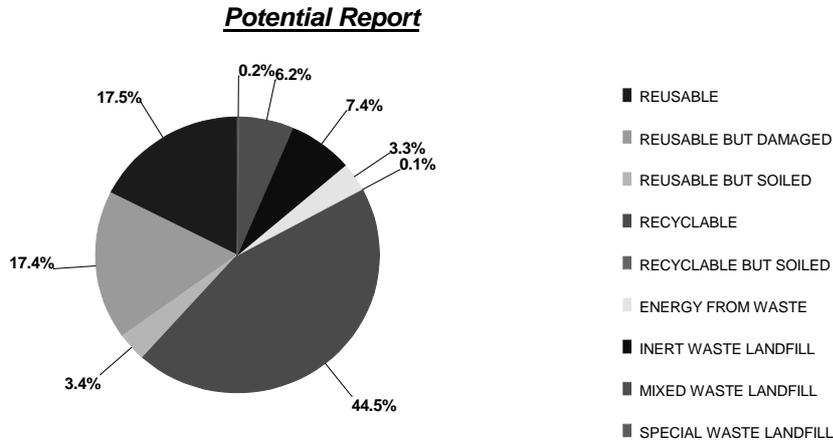
Extract from pre-demolition waste audits

	Dimensions (cm)			Waste Potential	Floor of Building						Total	Waste Potential	
	length	width	depth		1	2	3	4	5	6		Target %	Achieved %
Purpose built desks	145	75	71	Reusable	12	3	5	7	11	2	214		
Double electric socket 240V	15	9	5	Mixed landfill	300	213	245	209	129	120	1390		
Twin strip light (long)	120	20	10	Mixed landfill	180	176	189	125	135	187	1166		
Kitchen sink	105	53	33	Mixed landfill	4	3	2	7	3	5	198		
Copper pipes (m)	100	1	1	Recyclable	180	98	165	213	99	126	1055		
Ceramic tiles (m ²)	100	100	1	Inert landfill	165	178	156	288	168	85	1214		
Radiator	100	50	3	Recyclable	12	15	21	18	16	22	278		
Toilet	76	70	51	Inert landfill	6	6	4	8	6	4	208		
Door & frame	200	89	10	Energy from waste	28	22	24	30	22	28	328		
Chairs	80	50	50	Reusable	42	40	38	71	32	42	439		
Kitchen cupboard	100	70	40	Energy from waste	12	13	10	21	18	16	264		
Wall lights	25	20	10	Mixed landfill	22	24	4	16	12	22	274		
Timber window frame	226	160	10	Energy from waste	42	48	48	48	42	38	440		
Brick & concrete cladding (m ²)	126	84	25	Inert landfill	185	188	188	190	160	145	1230		
Steel heating pipe (m)	100	4	4	Recyclable	1223	1223	1200	1200	1820	1600	8440		
Slab, stairs, walls & chimneys (m ²)	100	100	20	Inert landfill	108	376	400	320	280	160	1818		
Water boilers	160	90	70	Mixed landfill	2	1	1	1	1	1	181		
Water tanks	200	70	70	Mixed landfill	0	0	0	1	1	2	178		

Quantity Report of the total quantity of waste by group prior to demolition



Reuse-Recycling Potential Report of the Waste prior to Demolition



Reuse-Recycling potential for all products (©SMARTWaste)

The next phase of this study is to visit a further 4-6 demolition sites during the next 10 months to undertake more pre-demolition or pre-refurbishment audits for four types of structure - concrete, steel, timber, masonry. This is a knowledge-gathering exercise of structures that will be used as case studies for the final report to DETR.

Construction

Until recently there was very little data on the nature of waste generation and it was typically all dumped into a mixed general skip for disposal. Construction waste is generated over a longer period of time than demolition waste, and is a minor consideration in the construction process. Attention is now shifting to waste arising through the construction process to address the need to be more efficient and profitable in order to compete and win new contracts.

Waste benchmarking

The maxim ‘In order to manage something you must first be able to measure it’ is certainly true of construction waste. Work is being carried out by BRE’s SMARTWaste, Bovis Lend Lease and other organisations to produce a more accurate evaluation of this wastestream.

Waste benchmarking in itself will not lead to greater resource efficiency. It is the first step towards waste reduction followed by reuse and recycling of materials back into the construction process and into other industries. This journey is not straightforward and may require implementation of many different strategies.

Key Performance Indicators (KPIs)

One such strategy is for the industry to compare its performance on a project, company and industry basis. Many construction clients (especially the UK Government) are committed to reducing the environmental impact of their developments. This has led to the development of a series of Key Performance Indicators that should include waste generation in the future.

This first stage requires an estimate of current practice against which targets for improvement can be made. Through waste benchmarking it has been possible to create the first set of figures for construction waste:

Project Type	Office	Housing (1)	Leisure	Housing	Hemp	Traditional	Restaurant	Office	Office	Office	Average Group KPI
	KPI	per Project Type									
Waste Group	m ³ / 100m ²										
Timber	0.201	0.804	0.058	1.650	0.095	0.000	2.667	2.518	2.232	1.195	1.142
Concrete	0.050	0.440	0.058	1.100	0.000	0.960	0.000	2.518	2.243	0.580	0.795
Inert	0.025	0.010	0.213	2.970	8.778	13.968	3.600	0.478	0.520	0.209	3.077
Ceramic	0.050	0.015	0.000	1.210	1.071	0.560	0.533	0.698	0.000	0.000	0.414
Insulation	0.226	0.495	0.174	0.110	0.000	0.000	0.000	0.992	0.451	4.282	0.673
Plastic	0.101	0.212	0.077	0.550	0.000	0.000	1.333	0.074	0.012	0.000	0.236
Packaging	1.182	0.445	0.949	0.990	0.557	0.464	4.267	3.694	0.590	1.033	1.417
Metal	0.151	0.253	0.058	0.110	0.000	0.000	0.000	2.775	0.832	0.557	0.474
Plaster & Cement	0.252	1.385	0.058	0.220	0.000	0.048	0.000	3.069	4.093	3.156	1.228
Miscellaneous	0.277	0.996	0.290	2.090	0.000	0.000	0.933	1.562	0.590	0.592	0.733
total KPI per Project Type	2.516	5.056	1.936	10.999	10.500	16.000	13.333	18.377	11.562	11.604	
Average KPI for all Projects											10.188

Source: BRE, Bovis Lend Lease

These figures are based upon a very limited set of projects and will change as more projects are evaluated across the range of construction and project types.

Waste reduction

The incentives to reduce waste include reducing costs, increasing efficiency and reducing environmental impact. These can be identified through the waste benchmarking process that can quantify the costs of waste in terms of:

- Cost of product wasted
- Cost of time to produce waste and clear it up
- Cost of disposal
- Environmental impacts associated with wasted product (including transport)
- Environmental impacts associated with waste management (including transport)
- Social impacts to local populations

Waste benchmarks and KPIs can also tie designers, contractors and sub contractors into minimum wastage rates. This provides an immediate incentive to seek and apply methodologies to reduce waste from design and procurement through to handover of completed works.

Initial benchmarking for a generic type of construction is an essential part of developing waste reduction action plans. With landfill tax funding from the Hanson Environment Fund and Biffaward, BRE has been able to carry out this process for several types of building. The findings will be disseminated to the construction industry to help them deliver more efficient products.

Examples of waste reduction can be categorised accordingly:

- Design – minimising offcuts through the use of prefabrication and standardisation
- Methods of work – making just enough mortar
- Packaging – use of optimal packaging that can be reused or useful in a different application
- Site management – having appropriate storage facilities.

Waste reduction strategies are often site specific, relating to the design or procurement of materials and products. To enable continuous improvement throughout the construction industry it is vital that all the major contractors develop their own internal mechanisms of designing, procuring and constructing in a resource efficient way.

Waste recycling and recovery

It is fair to say that the construction industry has not investigated the possibilities of recycling and recovery to the fullest and could save significantly in terms of reduced disposal costs and avoidance of landfill tax. Part of this is due to the focus of a construction site being to construct rather than manage waste; part is due to lack of data surrounding the cost of waste. Another major factor is also the constant relocation of the construction site resulting in new waste management contracts and varying facilities each time.

Work carried out by BRE on several construction projects has demonstrated the importance of requiring sub-contractors to participate in site segregation schemes as part of the tendering process if recycling is to be promoted. Where the requirement to segregate for recycling is introduced after the tendering process extra payment is typically demanded for the extra effort (perceived rather than actual).

The materials that can often be segregated for recycling include metals, timber, inert, paper and cardboard. In addition some of the material suppliers offer take back schemes for packaging, especially pallets, and material offcuts. A good example is that of British Gypsum, Lafarge and Knauf who all provide a take back recycling scheme for plasterboard offcuts. Additional take back schemes for mineral wool and polystyrene have also been identified. Where materials are being delivered continuously through the construction process these schemes reduce waste management costs significantly and resource recovery is increased with minimal transport impact

Future Developments

Key stakeholders in the construction industry are now committed to continuous improvement in terms of environmental impact, productivity and profitability. This can be achieved through greater resource efficiency. More construction projects are needed to provide real benchmarks and show practical ways to be resource efficient.

New techniques and tools can also facilitate this process. SMARTWaste has proved useful in establishing accurate waste benchmarks and priority areas for action. Its further development as a web-based tool with increased functionality will be complete by the autumn.

DETR is continuing to sponsor key research to help the construction and demolition industries identify and implement greater resource efficiency.

BRE Research and development projects in this area sponsored by DETR include:

- Identifying the Best Practicable Environmental Option with respect to construction and demolition waste management
- Improving the future recyclability of composite building products
- Creating markets for construction site packaging wastes
- The application of bioremediation and composting techniques
- Maximising the effective use of construction timber waste (partners in innovation project. Details of other successful PII projects on : www.pii.org.uk)

Further information

1. BRE: 01923 664856. Email hobbsg@bre.co.uk. <http://www.bre.co.uk>
2. BREWEB: <http://www.breweb.org.uk>
3. Construction Best Practice Programme. CPBB: 0845 605 55 56. <http://www.cbpp.org.uk>
4. Movement for Innovation. M4I: 01923 664820. Email support@m4i.org.uk. <http://www.m4i.org.uk>
5. Salvo: 01890 820333. Email: salvo@scotborders.co.uk. www.salvo.co.uk
6. EA waste book: <http://www.recycle.mcmail.com/content.htm>
7. Symonds report on EU construction and demolition waste: <http://europa.eu.int/comm/dg11/waste/report.htm>
8. CIB TG 39 Deconstruction. <http://www.cce.ufl.edu/affiliations/cib/index.html>
9. Construction Industry Environmental Forum CIEF: 020 7222 8891. http://www.ciria.org.uk/cief_events.htm

References

1. BRE IP 7/00 *Reclamation and Recycling – industry position report*. Hobbs G. & Kay T. CRC London 2000.

PREVENTING INDOOR AIR POLLUTION IN FINLAND

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INTRODUCTION

In Finland, due to our cold and northern location, people spend much of their lives time indoors. We therefore have to design buildings that shelter us against the adverse weather conditions, yet, at the same time, have good quality indoor air. The building itself, its design, construction, use and maintenance, can cause serious problems with indoor air. The need to build tight houses for energy conservation is not always easy to combine with the need for healthy indoor air quality.

Good indoor air quality (IAQ) is recognised as an important question of national health and national economy in Finland. In our cold climate, however, good IAQ must be combined with good energy economy. This is a real challenge for the public and private sectors. All actions for better IAQ, that is the governmental actions and the private sector ones must be well planned and coordinated to achieve in practice the goal of healthy indoor air combined with good energy economy and sustainability of buildings.

In Finland the businesses companies and organisations in the construction sector have participated actively in these actions. They have, among other things, developed construction materials and HVAC (Heating, Ventilation, Air Conditioning) devices with smaller emissions and have also developed better and more quality oriented construction practices. One essential tool, in use in Finland for five years, has been the classification system for IAQ and construction materials.

OFFICIAL REQUIREMENTS FOR INDOOR AIR QUALITY

Construction activities in Finland are regulated under the Land Use and Building Act. The Ministry of the Environment issues the Building Code, which consists of binding regulations and guidelines. Act and Building Code incorporate the requirements of European Union (EU) construction product directive. Some parts of the Building Code, namely, requirements for energy conservation, ventilation and indoor air, will be renewed this year with the aim of promoting more clearly the national and international policies on greenhouse gas emissions (e.g. the Kyoto Protocol) and of giving special support to sustainable construction. This also means that the IAQ requirements and requirements for energy conservation must be balanced in buildings in a proper way. Different effects of indoor air on health and comfort must be taken into consideration as well as different ways to save energy in the buildings. However, there will be no specific limits on harmful emissions from the construction materials.

The building regulations are supervised locally by the municipal building authorities, who give the building permit and who also control and guide the construction activities generally.

Air quality in buildings is regulated in accordance with the Health Protection Act under the supervision of the Ministry of Social Affairs and Health. The ministry gives detailed guidelines for defining air quality requirements in practice, for example, in the form of allowed maximum concentrations of impurities in indoor air. These guidelines are mainly based on the need to protect health and they follow to a large extent international recommendations, among others, WHO recommendations.

Local health authorities in the municipalities also supervise air quality requirements. The local authorities can also take measurements of indoor air quality in homes and state buildings, such as schools and kindergartens. Additionally they can give guidelines for renovation and if necessary even prevent the use of buildings with poor air quality before renovations.

THE IMPORTANCE OF CO-OPERATION BETWEEN PUBLIC AND PRIVATE INTERESTS AND ORGANISATIONS

Good indoor air quality is as important to the national economy and for public health as it is for the people living and working in the buildings. In other words, good IAQ is of interest to both the public and private sectors. In Finland we have seen that good IAQ cannot be achieved and maintained only by governmental measures. Government actions must always be combined with private measures to ensure the best healthy indoor conditions.

In particular the building owners and all parties participating in the construction process, among others, architects, engineers, construction workers and producers of construction materials must be aware of the risks of bad IAQ and must also have knowledge of ways to avoid it or minimise it.

The support and actions of many different public and private organisations have proven to be very important and effective for achieving better IAQ and healthier buildings. These groups are mainly voluntary, and they can reach some groups in the society, which are not easily reached by governmental officials. Frequently these groups receive support from the state.

The role of the Finnish Society for Indoor Air Quality (FISIAQ) has been helpful for and central to the development of good IAQ in Finland. The FISIAQ arranges national as well international events and also publishes scientific publications and guidelines for practical applications.

To help define the best targets for IAQ and to improve generally the quality of construction in Finland, the FISIAQ published the Classification of Indoor Climate, Construction and Finishing Materials in 1995. The work was done in close co-operation with experts from research institutes and branch associations of technology, building engineering and architecture on the initiative of and with support from the Ministry of the Environment.

THE FINNISH CLASSIFICATION OF INDOOR CLIMATE 2000

This classification is voluntary and not a part of the official Building Code. It has been prepared by researchers and other interested parties to aid building owners, architects, other designers, builders and manufacturers of materials and building components in achieving good indoor air quality. Besides the Ministry of the Environment, all main branch organisations in the building sector support and recommend the classification.

The classification has three main parts:

1. The classification of indoor climate, **categories S 1, S 2, S 3**, gives target and design values for thermal conditions, odour intensity, noise levels, ventilation and indoor air pollutants.
2. The guidelines for design and construction, including the classification of cleanliness in the construction, **categories P 1, P 2**, is composed of principles and procedures for the main stages of construction work.
3. The classification of finishing materials, **categories M 1, M 2, M 3**, contains maximum allowed values for harmful emissions from finishing and other construction materials.

In all these classifications, better indoor air quality correspond to a lower category number, and the higher numbers correspond the minimum accepted requirements for the IAQ in accordance with the official building regulations.

Construction clients, building owners and designers can use the classification as a tool in setting target values for indoor climate and in achieving these goals during the construction process. Especially the first part of the classification, dealing with the target values of indoor air quality, has been used widely by designers in various building projects.

It is especially important that the building owner or his technical representative defines the level of indoor air quality using the guidelines of the classification. He can select the class for all of the indoor climate factors; thermal as well as air quality related. Normally the selection of the best category **S 1**, for air quality necessitates that only materials of the best **M 1** class should be used. But in the whole construction process from the design to the construction work the decision-making must be quality- and health-oriented. Only by following these classification guidelines can the original aim of the classification system be guaranteed.

The second part dealing with guidelines for better construction and cleanliness has, unfortunately, not been followed too often. It is, however, more and more common that HVAC designers specify that the ducts have to be cleaned after the manufacturing process and handled on the construction site with capped ends. Additionally, the new requirement in classification system to have a moisture protection plan for the whole construction site is important.

The third part, the classification of construction materials, has been a real success in Finland, both in consumer and professional markets. By June 2001, more than 450 materials have been granted the label of the best category **M 1**. Manufacturers have significantly improved their products in order to meet the requirements and be able to use the **M 1** label in their advertisements. Today it is already possible to build a house using only M1 labelled finishing materials. These materials account for 10% - 20% of the whole market when counted numberwise, but nearby 50%, when counted as the sales proportion of the total market of construction materials. For more detailed information about the classification system see the website, www.rts.fi.

The classification has now been revised based on the collected practical experiences from the construction sector. The new version, **Classification 2000**, with many improvements has been published at the beginning of this year. The main improvement will probably be the introduction of the emission classification of ventilation system components. This expansion of the material **M** classification should result in reduced chemical and sensory emissions from ventilation systems. This is important for good IAQ and also for energy conservation because it helps to avoid unnecessary high ventilation air flows.

One important effect of the whole classification system is that the overall quality control of construction work is emphasised.

THE CLASSIFICATION OF CONSTRUCTION MATERIALS

To avoid harmful emissions to indoor air, all construction materials and specially the finishing materials must be selected so as to keep these emissions under control. Therefore, the use of category **M 1** materials is necessary for achieving the indoor climate category **S 1**. Non-labelled materials or other emissive materials can only be used in very small quantities. Category **M 2** materials can be used more, up to 20% of the total amount of finishing materials in a room. Natural materials like stone, wood, glass, ceramic tiles and bricks can be used quite freely. However, the VOC emissions of the fresh wood in new buildings may be quite high; therefore these emissions must be controlled if wood is used over large surface areas.

Unfortunately, the use of only low-emitting materials does not always guarantee good air quality in rooms. Ventilation also has to be adequate and the materials should be used according to the manufacturers' specifications. For example, very few materials can tolerate being exposed to excessive moisture. Materials should also be easy to clean.

Requirements for construction materials

Category M 1: Category M 1 is designated for materials which fulfill the following requirements: 1) The emission of total volatile organic compounds (TVOC) is below 0.2 mg/m³h; 2) The emission of formaldehyde is below 0.05 mg/m³h; 3) The emission of ammonia is below 0.03 mg/m³h; 4) The emission of carcinogenic compounds (due to IARC) is below 0.005 mg/m³h; 5) Material is not odorous (dissatisfaction with the odour is below 15%).

Category M 2: 1) The emission of total volatile organic compounds (TVOC) is below 0.4 mg/m³h; 2) The emission of formaldehyde is below 0.125 mg/m³h; 3) The emission of ammonia is below 0.06 mg/m³h; 4) The emission of carcinogenic compounds (due to IARC) is below 0.005 mg/m³h; 5) Material is not strongly odorous (dissatisfaction with the odour is below 30%).

Category M 3: This category is for materials which do not have emission data or the emission data exceed the values specified for materials of category M 2.

Labelled materials must have a product specification which should present emission data and possible limitations for the use of the material and also requirements for the environmental conditions where the material is applied. The manufacturer must also have an acceptable quality control system.

The measurement of emissions should be performed when the material is in the final form in which it is used. Material emissions should be measured according to the proved and specified methods. The sampling and analyses of the emissive chemicals and the sensory tests have to be made according to commonly accepted and published methods, specially the methods of ISO and CEN are used if these only exist. Emissions of materials should be measured after four weeks from the date of the production or the date when the material is unwrapped from the air tight packing. The samples should be stored for four weeks before the test in a climate chamber. The time of four weeks will be calculated for paints, levelling agents, adhesives, sealant, among others, from the date of application on the surface of the material.

EXPERIENCES FROM THE USE OF THE CLASSIFICATION OF IAQ AND MATERIALS IN FINLAND

The classification of indoor air quality and of the materials according to their harmful emissions has now been used in Finland for five years. The system has proven to function in practice. Buildings with better IAQ, and also falling into the best category **S 1**, have been built and the IAQ conditions in them have been

tested. Better IAQ has been achieved. Although better IAQ may require some extra cost, this has been only some percent of total building costs and very negligible when compared with the life-cycle costs and specially with the advantages better IAQ gives to the users of the building.

One important issue in this process is that the manufacturers and importers of construction and finishing materials have, during these years, improved the quality of their products so much that the harmful emissions has been lowered drastically and, in some cases, for many decades to come. The domestic as well as foreign firms have develop new products with lower emissions by using better technology in production and cleaner receipts and by laying more emphasis on product quality control.

The whole process has shown that buildings with better IAQ are possible to construct using private, volunteer actions, when co-ordinated and supported with governmental actions. Throughout, the Ministry of the Environment has supported this classification of IAQ and construction materials. The system functions well and complements the governmental regulations, but needs less official supervision. The awareness and knowledge of IAQ and the problems have been the first step and the competition between the different manufacturers of construction materials will be the second step.

But there have also been problems in introducing the classification system in practice. At first the producers were not very eager to carry on the tests for the labelling of their products. However, over time they realised that the costs of these tests are very limited compared with the advantage in the marketing of their products. The manufacturers are now taking part to a greater extent in the system.

One important challenge has been how to target the right groups so as to inform the different parties of the classification system and new products. Professionals, such as building owners and architects, need information in a different form than do individuals, who buy the paints, sheets and other products in the shops.

The construction sector tends to be quite conservative and changes in attitude are not easy to achieve. Additionally, the co-ordination of the measures from different sectors has proven to be necessary and effective when combined with the general spreading of IAQ information and dissemination of indoor air quality knowledge.

FUTURE PLANS AND NEEDS

The classification of IAQ and construction materials has proven to be a well functioning system. It has shown that private voluntary actions do help in improving IAQ in buildings. Government co-operation and support has also proven to be important and the aim of avoiding unnecessary regulations has succeeded. The new proposal for indoor air quality requirements in the Building Code will in many ways emphasise the value of good IAQ for the people and for sustainable buildings. However, there will be no limits set on the emissions from construction materials because harmful emissions are already being reduced now.

But much better results may have been achieved if a similar classification system functioned internationally. Then, the manufacturers of the construction materials and components would be more inclined to improve and test their products. Unfortunately, no such system seems to be in developing internationally. Quite similar classification or labelling systems, but more limited, are in use in some other countries, but the real need is to develop an internationally accepted classification system or at least a European one. Finland is ready to co-operate and participate in all actions of this kind. The first step here could be the international acceptance and comparability of the test methods for construction product emissions. The work of the ISO and CEN should be still more activated and directed to develop internationally accepted methods for chemical and sensory tests.

Finland is also ready to share our experiences with other countries in the problems of disseminating information on IAQ and developing a functioning classification system. We believe that the requirements for the emission tests methods and the limit values for impurities as well as the selection of the tested substances are not so important as long as they are successful in guiding production and use of the materials in the right direction, that is, to have lower and less harmful emissions to indoor air. For the more and more globalising manufacturing industries these requirements must be open, clear and as harmonised as possible, so that these industries have a reliable base from which they can develop their products and materials.

Finland also believes that good quality indoor air must be seen as an essential factor of sustainable buildings. The trends towards sustainable development and reduction in the use of, among other things, global resources and energy must be combined with a good and healthy indoor environment. We feel it to be so important that in our competitions for sustainable buildings good IAQ has been a major factor in the judging. As an example, this year in one large Finnish competition to develop and build sustainable detached houses all the winners promised to build their houses to have an indoor air quality in the category **S 2** and to use in the buildings only **M 1** labelled construction materials.

U.S. EPA'S INDOOR ENVIRONMENTS PROGRAM: A CASE STUDY FOR THE OECD

by Ken SANDLER

US Environmental Protection Agency

Background

The U.S. Federal government first began to recognize poor indoor air quality as a serious environmental concern in the early 1980s. Research at the U.S. Environmental Protection Agency (EPA) and elsewhere, from that point on, uncovered health risks related to poor indoor environmental quality (IEQ) that include:

Asthma: a virtual epidemic in the United States, this disease now affects an estimated 17 million Americans. The death rate from asthma has increased 33% in the last decade, reaching approximately 5,000 deaths per year. American children are particularly vulnerable to this problem: asthma has increased 160% among children under the age of five, affecting one out of every thirteen children in the U.S. All of this is very costly to society: annual costs, including medical costs and lost productivity, are estimated at \$11 billion per year.

Cancer: Several indoor contaminants, including radon and environmental tobacco smoke, are known carcinogens, while other indoor contaminants, including some pesticides, are suspected to be carcinogens. Radon is the second leading cause of lung cancer in the U.S., causing between 15,000 and 22,000 deaths annually. Environmental tobacco smoke (also called "secondhand smoke") is estimated to cause 3,000 additional deaths per year.

Carbon monoxide (CO) poisoning, from the improper use and maintenance of fuel-burning appliances and other indoor sources, kills over 800 Americans per year.

Developmental and reproductive effects: Toxins including lead, tobacco smoke and some pesticides can impair the development of fetuses and children. Some indoor environmental agents are believed to have effects on human reproductive capabilities as well.

Other effects: Biological contaminants like mold can cause a variety of health effects, including allergic reactions, asthma and irritations of the eyes, nose and throat.¹

All of these problems are exacerbated by the facts that Americans spend approximately 90% of their time indoors and indoor pollutant levels are often 2-5 and sometimes 100-1,000 times higher than outdoors. Considering all of these health impacts, several risk-ranking projects of the U.S. EPA and other Federal agencies have identified indoor air pollution as one of the top environmental risks to human health.

1. IEQ health effects information from U.S. EPA's *Healthy Buildings, Healthy People: A Vision for the 21st Century* < <http://www.epa.gov/iaq/hbhp/>>.

In response to these findings, the U.S. Federal government has spent the last decade and a half developing an indoor environmental quality program. While the remainder of this case study focuses primarily on the work of the U.S. EPA's Indoor Environments Division, other Federal agencies that partner with EPA on this issue include: the Department of Health and Human Services, the Consumer Product Safety Commission, the Department of Housing and Urban Development, the Occupational Safety and Health Administration, the Centers for Disease Control and the National Institutes of Health.

U.S. EPA's Indoor Environments Program

The first indoor environmental problem to cause significant public health concerns in the U.S. was that of radon. In 1985, EPA responded by creating the Radon Action Program. The following year, the U.S. Congress passed the Radon Gas and Indoor Air Quality Research Act. This law required that EPA submit a Report to Congress on Indoor Air Quality, which was completed in 1989. This Report characterized the nature and magnitude of indoor air quality problems in the U.S. and developed a blueprint for future work in the field.

Since the Report to Congress, EPA's IEQ staff has grown from less than ten to nearly 90 (including staff in EPA's 10 Regional offices) and its budget has increased to over \$10 million. The official mission of the program is to: "Reduce the public health risks of indoor environmental problems." Furthermore, in accordance with the Government Performance and Results Act, which requires that government programs set quantitative goals, the primary goal of the IEQ program is: "By 2005, 15 million Americans will live in healthier indoor environments." (There are also more specific goals on such issues as asthma and schools.)

EPA's Indoor Environments Strategy has three key elements. First, it emphasizes minimizing exposure to indoor contaminants, through the reduction of source-specific risks such as radon and tobacco smoke and the improvement of building design, operation and maintenance. Second, it focuses on using the best available information to create practical guidance, training and public information on IEQ. Third, it involves working with public and private sector partners to implement exposure and risk reduction through IEQ issues education, training and promotion.

EPA's major IEQ programs may be broken out in various ways. There are programs aimed at improving the indoor environments of particular building types, including homes, large commercial (e.g., office) buildings, and schools. There are programs organized around specific health effects, most notably on the issue of asthma. And there are educational materials, and more extensive programs in some cases, organized around particular pollutants, such as radon, secondhand smoke, biological contaminants (including mold), carbon monoxide (CO), particulates, pesticides, formaldehyde, volatile organic compounds (VOCs) and lead. Several of EPA's most developed IEQ programs in these areas are discussed below.

By Building Type

Large Commercial Buildings

EPA has conducted two extensive studies of the indoor environmental quality of office buildings <<http://www.epa.gov/iaq/base>>. The Building Assessment Survey and Evaluation (BASE) involved a cross-sectional study of 100 buildings, the largest such study ever conducted. The data from this study is

scheduled to be released in Summer 2001.² Also, EPA's Office of Research and Development concurrently conducted a study of the IEQ of Federal buildings entitled Temporal Indoor Monitoring & Evaluation (TIME). Once the data from both studies has been completely analyzed and reported, it will greatly expand knowledge and understanding of the nature of IEQ in office buildings.

EPA also has produced materials to help building owners, managers and occupants better understand and reduce indoor environmental threats. For building owners and managers, EPA has developed a Building Air Quality Guide, Action Plan and Training Kit. The Guide, developed in conjunction with the National Institute of Occupational Safety and Health, provides information on common building IEQ problems, and how to investigate and mitigate such problems. Key topics covered include heating, ventilation and air conditioning systems, moisture problems, and air quality sampling.

The Action Plan informs Building Owners how to implement IEQ improvements, following 8 steps and a 100-item checklist. The Training Kit was developed by the Building Owners and Managers Association International (BOMA), through a grant from EPA. BOMA, which represents over 7,000 office building owners, managers, developers, facility managers and leasing agents, developed and promoted the training to its members, helping to dramatically spread the dissemination of this information. EPA also funded the International Union of Operating Engineers, which represents 370,000 engineers, to create a training course on sound indoor air quality management. Hundreds of engineers have taken this course, which has been implemented into the Union's standard curriculum.

Homes

Improving IEQ in homes represents an even greater challenge, because of the much larger number of buildings and audiences involved, including homeowners, builders, real estate agents and home inspectors. EPA has materials and programs to educate all of these groups on IEQ issues.

To inform homeowners and renters on IEQ issues, EPA has developed a program called Healthy Indoor Air for America's Homes. This program utilizes a nationwide network of over 3,000 county Cooperative Extension Services, whose personnel have been trained with EPA materials, to educate consumers directly. Specific practical information is provided, for example, on how to make kitchens, bathrooms, bedrooms and other areas of the house free of mold and other hazards. The information campaign is particularly intense in October, which has been declared National Home Indoor Air Quality Action and Awareness Month. EPA also provides extensive information to the public on home IEQ hazards on its website <www.epa.gov/iaq>.

EPA provides additional information geared to home builders and remodelers on how to improve home indoor environments. For builders, there is a web page dedicated to the issue of radon-resistant new home construction <<http://www.epa.gov/iaq/construc.html>>.

The information provided includes model standards and techniques as well as architectural drawings. For remodelers or homeowners conducting their own remodeling, there is also a web page <<http://www.epa.gov/iaq/homes/hip-front.html>> with specific information about how to ensure that changes to different parts of the home (kitchen, basement, ventilation system, etc.) improve rather than degrade IEQ.

2. To receive notice of the release of this information, send your name and address via e-mail to <burton.laureen@epa.gov>.

Schools

EPA's IAQ Tools for Schools program <<http://www.epa.gov/iaq/schools>> provides a comprehensive approach to improving the indoor environments of America's 115,000 elementary and secondary schools. The Tools for Schools Kit includes a guide to coordinating improvements at one's school, checklists for upgrading IEQ, and a video covering such issues as the importance of proper ventilation. In conjunction with this Kit, EPA has developed two training modules to educate and inspire district school officials to lead efforts at their schools for indoor environmental improvement. Numerous state and local health departments, as well as chapters of such organisations as the American Lung Association, use these modules to provide training in locations throughout the U.S.

There is a yearly National Schools Symposium, sponsored by EPA, that brings together school board officials, administrators, school nurses, teachers, facility managers, school and health association members, parents, and others to discuss and learn more about how to improve IEQ in schools. EPA also has Excellence Awards for schools in each of EPA's ten regional areas that have made notable progress in improving their IEQ. Finally, EPA has established partnerships with numerous national educational and health associations to inform, broadcast and advance its IEQ message.

By Health Effect

Asthma

Asthma reduction has become an important goal of EPA, in response to the severity of the problem in the U.S. and increased evidence of links between IEQ and asthma. EPA's asthma program focuses on alerting Americans, especially parents, to the problem and educating them on how to better manage it. EPA has established a partnership with the Ad Council to develop television public service announcements about childhood asthma, and directing viewers to a website where they can obtain more information. EPA has also established partnerships with numerous health care associations to help educate the public on these issues. There is additional information on EPA's website <<http://www.epa.gov/iaq/asthma>> about the causes of asthma, common asthma triggers in the home and how to eliminate them.

By Pollutant

Radon

Radon was the first IEQ problem targeted by EPA, and it remains an important part of EPA's Indoor Environments program. EPA's Radon Action Program began in 1985. Its goal was to build the understanding and capacity of state governments and private organisations to reduce the risks of radon in homes. Following passage of the Indoor Radon Abatement Act in 1988, EPA made funding available to States to develop and operate radon reduction programs, and provided a Radon Contractor Proficiency Program to train radon measurement and mitigation contractors. This program more recently has been turned over to the private sector.

Today, EPA's Radon program <<http://www.epa.gov/iaq/radon>> focuses on educating the building community, citizens and health care providers on the hazards of radon, and how to identify and reduce them. For the building community, in addition to the Radon-Resistant New Construction guidance for builders mentioned previously (section A.2.), there is detailed information aimed at real estate agents and home inspectors on the technical, financial and health implications of radon. There is also a Physician's Guide to inform doctors on medical issues related to radon. For homeowners, apartment tenants and other

citizens, there are: a television public service announcement to urge people to test their homes for radon; informational materials on the problem, including maps of which regions tend to have the highest radon levels; and a Hotline to answer their questions.

Environmental Tobacco Smoke

In 1993, EPA released a historic risk-assessment study concluding that secondhand smoke causes lung cancer in nonsmoking adults and increases the risk of bronchitis, pneumonia, and asthma in children. Since then, EPA has developed a program to educate parents, child-care providers and others on the risks of environmental tobacco smoke (ETS) and how to prevent them <<http://www.epa.gov/iaq/ets>>. This program includes educational materials and television public service announcements to raise awareness on the issue. In particular, EPA recently launched a Smoke-Free home Pledge campaign to encourage parents who smoke to do so outdoors, so as to spare their families, and particularly their children, the health effects of secondhand smoke.

Conclusion

EPA's Indoor Environments program has, in a little over a decade, developed a comprehensive attack on the problem of poor IEQ. Parents, teachers and other school officials, doctors, builders, real estate agents, home inspectors, building owners and managers, state and local government officials, and other audiences are being made aware of IEQ problems, the health implications of these problems, and how to prevent, mitigate or eliminate them. Through partnerships with associations representing many of these groups, EPA is working to get this information incorporated into standard practices of construction, remodeling, building management, school administration and health care practice. The results of this effort are demonstrated through such examples as the schools that have received EPA's IAQ Excellence Awards for implementing significant changes in the structure and/or management of their school buildings to improve their indoor environments.

CURRENT STATUS OF INDOOR AIR POLLUTION BY CHEMICAL COMPOUNDS IN JAPAN AND THE POLICY MEASURES BEING TAKEN BY THE JAPANESE GOVERNMENT

by Shuzo **MURAKAMI**

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Abstract

In recent years health problems caused by exposure to low level and long-term indoor air pollution, known as "sick house syndrome", are causing great public concern in Japan. Governmental policies should take an important role in addressing this problem, however, there are many obstacles to the design of effective and efficient policy instruments in this area. After explaining the current status of indoor air pollution in Japan, obstacles to the design of effective policies will be examined, as well as policy options that governments can take. Up-to-date information on the development of Japanese governmental policy in this area will also be presented.

1. Introduction

Indoor air pollution caused by chemical compounds is known as "sick house syndrome" in Japan. It is now a very serious problem in Japan and has become a matter of great social concern. Low level and long-term exposure to chemicals harmful to the human body produces the symptoms. This is a new type of disease that human beings have not suffered from before now. In the 21st century, human beings will be forced to face various health problems caused by such low level exposure to artificial products, including chemicals. This may be a side effect of life-styles that involve excessive consumption of artificial products. "Sick house syndrome" may be the prelude to a kind of war between the living environment and chemical products that will be waged in this century. In this context, WHO (World Health Organisation) published the Statement for healthy indoor air, the header sheet is shown in Fig. 1.

Fig. 2 illustrates the number of articles related to "sick-house syndrome" which have appeared in the Asahi Newspaper. The recent increase in article numbers is remarkable, reflecting the extent of social concern.



Fig. 1 Statement by WHO for healthy indoor air

The MLIT (Ministry of Land, Infrastructure and Transport) of the Japanese Government carried out an extensive survey of chemical concentrations in 5 thousand houses in the year 2000. Results showed that 25% of the houses surveyed exceeded the guideline of formaldehyde (0.1 ppm) and 10% exceeded the guideline of toluene (0.07 ppm (260µg/m³)). In Japan, the Government, academic bodies, and industrial sectors are doing much collaborative research and also are making great efforts to find effective

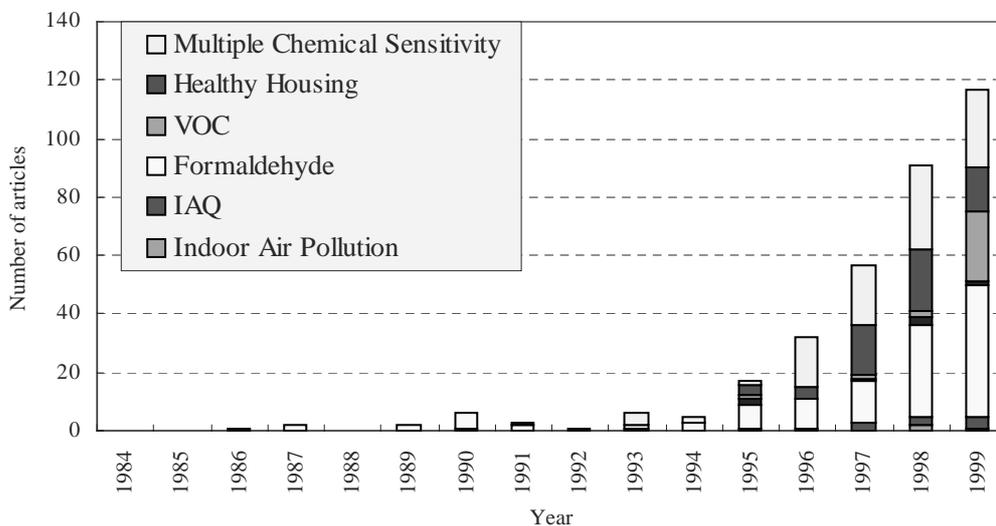


Fig.2 Increase in number of newspaper articles related to "sick-house syndrome"

(Source: Asahi Newspaper)

countermeasures to this problem.

2. Background to the problem

Three points can be identified as the background causes of so-called “sick house syndrome.”

- Decrease of air change rate in rooms due to the improvement of air-tightness in buildings, particularly in residential buildings.
- Increase of building materials, materials used in the construction process (adhesives etc.), furniture and daily-life necessities, which include chemical compounds harmful to the human body.
- Increase in the number of people who are very sensitive to low concentrations of chemical compounds. This tendency is similar to the increase of patients of allergies or atopic dermatitis.

An inter-disciplinary research organisation is required to help to overcome this problem as it includes many inter-disciplinary issues such as building science, medical science, chemical science and environmental engineering etc.

3. Difficulties in implementing government policies concerning sick house problem

Although it is necessary for the Government to introduce various policy instruments to cope with the sick house problem, it is very difficult to find effective measures due to the following reasons:

3-1 The mechanism or mechanisms responsible for the appearance of multiple chemical sensitivity symptoms are not yet sufficiently known from a medical viewpoint. The arguments concerning the definition of this disease have not yet been settled in the medical field.

3-2 The tolerable concentration of the various chemical compounds within room air is uncertain. On the other hand, it is a highly urgent matter for the Government to publish the values of the maximum permissible doses, as the public greatly desires to be aware of these values. Thus, for the present, these values are often based on animal experiments made in the past. The scientific foundations of these values are not altogether robust.

3-3 The prediction of the concentrations of chemical compounds within a room at the design stage is very difficult. The mechanisms of emission, diffusion and exhaust of chemicals in a room is very complicated, as illustrated in Fig. 3. Thus, it becomes very difficult to know whether the concentration of room air satisfies the tolerable values at the stage of building design, even if the guidelines for tolerable concentrations are published. The reasons for this difficulty are shown below:

- The prediction of air change rate of an occupied room is very difficult, particularly in the case of natural ventilation.
- The prediction of the emission of chemical compounds from the building materials used in rooms is also very difficult. Data concerning the emission rate of chemicals from each building material is now being prepared. However, it is difficult to predict the emission rates when the materials are built into the buildings using various construction methods.

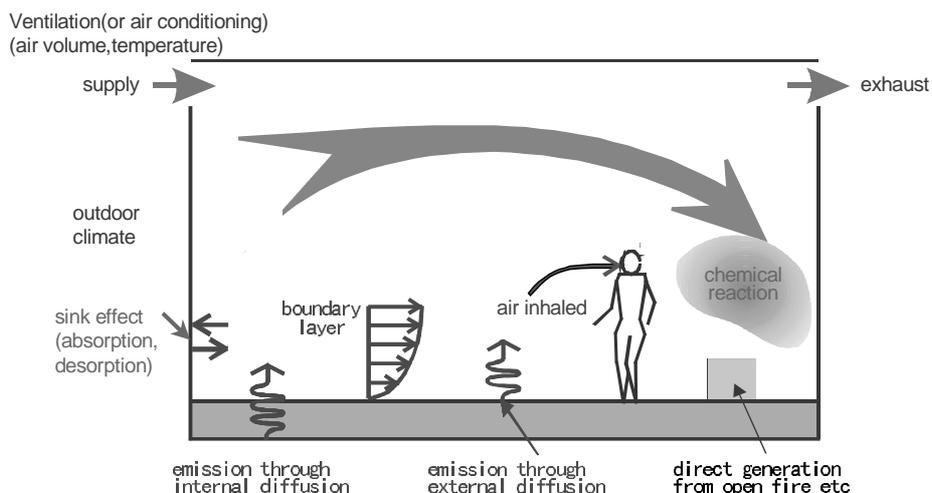


Fig. 3 Mechanism of emission, diffusion and exhaust of chemicals within a room

- It is difficult to predict emission levels from furniture and daily-life necessities brought in by the occupants. Thus there is considerable uncertainty as to how much a building is responsible for indoor air pollution. There are a variety of emission sources of chemicals in a room, as shown in Fig. 4.

As it is very difficult to predict the room-air concentration of chemical compounds at the design stage, it is also difficult for the Government to take effective regulatory measures based on room-air concentrations of chemicals.

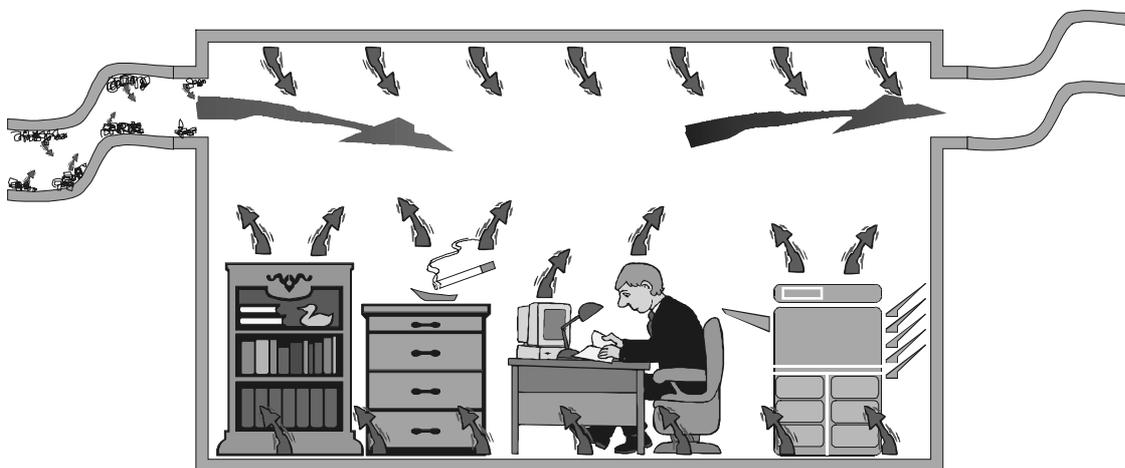


Fig. 4 Various emission sources of chemicals in a room

4. Countermeasures taken by the Government

Various policy instruments, e.g. regulatory measures, economic incentives, performance indication systems, dissemination of information, etc. can be selected to deal with indoor air pollution problems.

The seriousness of indoor air pollution varies greatly from room to room in sick houses. Thus the amount of the overall reduction of emissions of chemical compounds does not become a matter of concern. This situation is different from the issues concerning the reduction of energy consumption or reduction of CO₂ generation. In this context, the policy to be selected is limited, but such a policy could be very effective if proper countermeasures were to be taken.

The type of buildings to which the policy measures should be applied may include; 1) residential buildings, 2) schools and 3) office buildings, that is, buildings in which people spend long periods of time.

The possibilities for practical countermeasures including regulatory ones, economic incentives, recommendations and the dissemination of information, etc. are as follows:

4-1 Providing reliable information concerning the various aspects of “sick house syndrome” to the general public, in order to prevent misunderstandings on the problem.

4-2 Preparation of a manual for a chemically-safe style of living for the general public.

4-3 Preparation of design guidebook for builders and for manufacturers of building materials.

4-4 Preparation of a design guidebook for effective ventilation systems both for mechanical ventilation and natural ventilation. An increase in air change rate may conflict with energy conservation policy.

4-5 Labelling system of healthy building materials to support incentives for the development of such materials and also incentives for the preferential-use of such materials.

4-6 Regulations prohibiting the use of unhealthy building materials.

4-7 Introduction of incentive loans for the use of healthy building materials and for well-designed ventilation systems.

Several policy instruments could be combined, because the application of a single regulatory measure may present a barrier to the flexibility of building design.

5. The current status of regulations or guidelines etc. taken by many OECD countries

Table 1 shows the current status of regulations, guidelines etc. taken by many OECD countries. The policies adopted in each country are diverse, ranging from clear regulatory measures (e.g. Finland) to systems offering technical information (e.g. USA), as illustrated.

Policies for formaldehyde are pretty well prepared. Many countries follow the guideline of WHO (0.08ppm) in general. But the treatment of VOCs guidelines is very diverse.

Table 1 Various policies adopted by OECD countries, regarding formaldehyde and VOCs

	Formaldehyde	VOCs etc.	Guideline by industry etc.
Germany	Regulatory measures executed (below 0.1ppm)	Regulation of VOC for industrial environment 1/10 1/100 of above mentioned permissible concentrations for non-industrial environment	<input type="checkbox"/> Self-imposed control on indoor VOCs concentrations by industries (RAL)
England			
USA	Below 0.1ppm for indoor air (IAQ guideline by EPA), no regulation		
Australia	Below 0.1ppm for TVOC of indoor air (guideline by a federal government committee)	for TVOC below $500\mu/m^3$ for indoor air guideline by a federal government committee	<input type="checkbox"/> Movement for preparing self-imposed control by plywood associations
Canada	Below 0.1ppm (IAQ guideline for housing)		
Austria	Below 0.5ppm for industrial environment (recommendation) Below 0.08ppm for indoor concentration in housing (recommendation)	Recommendation by the government	
Finland	Below 0.13ppm (regulation)	Program for introducing guidelines for Styrene and Ammonia	
Denmark	Below 0.13ppm (regulation)		
Netherlands	Below 0.1ppm		<input type="checkbox"/> Labelling system by VIBA
Japan	Below 0.08ppm (guideline by the Government)	Below $400\mu/m^3$ for TVOC (guideline by the Government, tentative) Guidelines for Toluene, Xylem, Para dichlorobenzene, Ethyl benzene, Styrene, Chlorpyriphos, Di-n-butyl phthalic acid (cf. Table 2 and 3 in the Appendix)	
WHO	Below 0.08ppm	Below $300\mu g/m^3$ for TVOC Guidelines for various kinds of VOCs	

6. Policies and actions taken by the Japanese Government concerning the sick house problem

The Japanese Government, with the participation of the MLIT (Ministry of Land, Infrastructure and Transport), the MHLW (Ministry of Health, Labour and Welfare), the METI (Ministry of Economy, Trade and Industry), the FA (Forest Agency), the MEXT (Ministry of Education, Culture, Sports, Science and Technology) and the ME (Ministry of the Environment) etc, is now adopting a number of measures and actions to overcome “sick house syndrome”. Local governments, such as the Tokyo Metropolitan Government, are also taking necessary measures independently. Details of the measures and actions taken by the MLIT, the MHLW, the METI, FA and the MEXT are described in the appendix.

Important measures led by the MLIT are described as follows:

6-1 Major research projects: Research committee for the “Healthy House”

In 1996, the MLIT set up a research committee called the “Healthy House Research Committee” with the participation of the MHLW, the METI, and the FA, as well as with experts and associations of related industries. As a result of the extensive research the committee drew up the following publications in 1998.

- Design and construction guidelines for home builders
- Users’ manual for consumers

These publications were distributed to constructors and consumers through local governments, associations of related industries, and regional health centers.

6-2 Establishment of the Housing Performance Indication System

In 1999, the MLIT established the “Housing Quality Assurance Act”, for indicating the performance of housing. This law aims to ensure various performances of housing, e.g. performance of structure, performance of fire protection, performance of IAQ (Indoor Air Quality), performance of energy consumption etc. In this law, formaldehyde emissions from interior finishing materials used for living rooms, bedrooms, etc. and finishing materials used for closets and furniture built into these rooms are evaluated and indicated based on formaldehyde emission grading methods, specified in the Japanese Industrial Standards (JIS) and the Japanese Agricultural Standards (JAS). Thus, the Law evaluates the grade of the building materials, such as plywood and particle board, according to the emission levels of formaldehyde, in order to predict the IAQ within the constructed houses. The law took effect in 2000.

Other measures and actions taken by the MLIT are described in detail in the appendix.

7. New policies being undertaken now by the MLIT (Ministry of Land, Infrastructure and Transport)

In the light of the fact that the issue of the IAQ has been drawing more and more public concerns, the MLIT is considering the introduction of two measures to cope with the issue.

7-1 Revision of the standard based on the Housing Quality Assurance Act

As previously mentioned, the formaldehyde emission from interior finishing materials is evaluated and indicated in this law. The MLIT is now about to revise the standard based on the Housing Quality Assurance Act. The main point of the coming revision is to add measurements of chemical compounds, such as formaldehyde, toluene, xylene, ethyl benzene and styrene. Measurement of formaldehyde concentration is mandatory, others are not mandatory. Measuring conditions are also required to be recorded.

7-2 Revision of the Building Standard Law of Japan

The MLIT is now planning to revise the Building Standard Law, from the viewpoint of the regulation of chemicals in building materials, which may chemically affect the health of occupants. In this context, the following issues are being discussed:

- The types of buildings and rooms to be regulated regarding the use of healthy building materials, e.g. residential buildings, schools, office buildings etc.
- The amount of air change that can be expected within occupied rooms of the buildings mentioned above. Estimation of the amount of air change is necessary to predict the indoor concentration of chemical compounds.
- Types of building materials that should be regulated, e.g. the finishing materials directly facing the rooms, materials used in the space above the ceiling or those under the floor etc.
- Types of chemical compounds that should be regulated.
- How to treat the emission of chemical compounds from furniture or closets etc. brought in by the occupants.
- How to deal with non-healthy building materials used in existing buildings.

8. Barrier to effective measures - lack of basic research and techniques necessary for policy makers and action planners

Members of MLIT who are in charge of making policies and actions often face practical difficulties when they want to take them, because of the lack of basic researches and techniques. The development of researches and techniques by scientific bodies has not caught up with public demand for the Government to take appropriate action. Major matters related to these difficulties are shown below:

8-1 Lack of medical data concerning MCS (Multiple Chemical Sensitivity) and maximum permissible doses of chemicals

The mechanism of MCS is not yet clarified from the medical viewpoint as already mentioned. Thus the scientific foundations for establishing the guidelines of tolerable concentration are not robust enough.

8-2 Lack of estimation technique of indoor concentration of chemicals at design stage

As already mentioned, it is very difficult to predict the indoor concentrations of various chemicals at the design stage. This makes it difficult for policy makers and action planners to take effective countermeasures. It is hoped that the technique for estimating indoor concentrations will quickly improve.

8-3 Lack of database of emission of chemicals from building materials

A database of chemical emission from building material is lacking in Japan. The designers of buildings and furniture need such data urgently, and such a database which includes a wide scope of materials should be published without delay.

8-4 Lack of technique for renovating existing "sick houses"

There are about fifty million residencies in Japan, including detached houses and apartments, as shown in Fig. 5. Some of them are so-called "sick houses." A huge number of "sick houses" are in existence in Japan. However no effective methods for renovating such houses has yet been established. The development of this technique is urgently needed.

8-5 Lack of emission data from furniture and daily-life necessities brought in by the occupants

Chemical emissions from furniture and daily-life necessities contribute significantly to the increase of indoor air pollution. The amount of emission from such materials varies greatly from one life-style to another life-style. Thus it is very difficult to estimate the total amount of emission of chemicals from buildings and furniture and daily-life necessities.

9. Concluding remarks

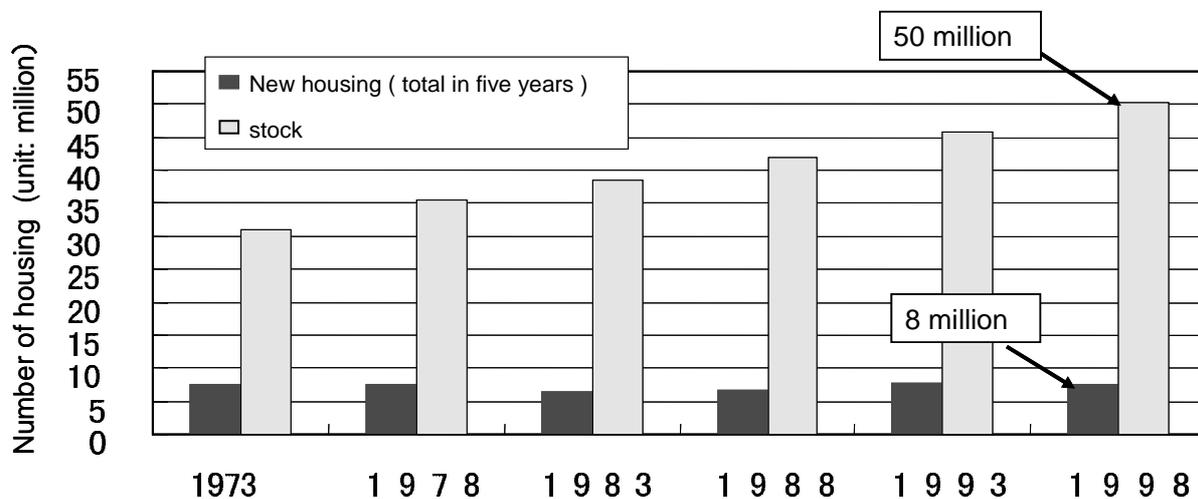


Fig. 5 Number of housing in Japan: new ones and the stock

As the sick house problem has become a matter of great social concern, it is urgently necessary to establish appropriate policy measures. The Japanese Government is making a great effort to respond to this need. The Government has been forced to publish various measures even before the academic fields of medical science, chemical science and building science etc. have resolved the many issues related with the sick house problem through far-reaching investigations. It often takes far too long for the academic field to answer such questions with sufficient scientific accuracy. In this context, the research work being undertaken in academic fields to clarify the problems of indoor air pollution are expected to be advanced greatly and rapidly, and thereby the scientific foundation of the measures taken by the Government will be more robust.

Appendix. Policies Adopted by and Actions taken by the Japanese Government

1. Policies adopted by and actions taken by the MLIT

The MLIT (Ministry of Land, Infrastructure and Transport) has been most active in taking a variety of measures concerning the sick house problem. Its major achievement has been to establish technical guidelines for builders and for facility manufacturers, which are used to assume the environmental conditions defined in the MHLW's (Ministry of Health, Labour and Welfare) guidelines.

1-1 Major research projects: Research committee for the "Healthy House"

In July 1996, the "Healthy House Research Committee" was set up, which includes the MLIT, the MHLW, the METI, and the FA of the Japanese Government, as well as experts and associations of related industries. In April 1998 the committee drew up the following publications as a result of its research.

- Design and construction guidelines for home builders
- User manual for consumers

These publications were distributed to constructors and consumers through local governments, associations of related industries, and regional health centres.

1-2 Administrative guidance to related industries for establishing the finishing material selection guidelines

In March 1999, the semi-governmental organisation "Japan Federation of Housing Organisations", established guidelines for the selection of finishing materials in which the builders were required to select building materials that were ranked in the lowest pollutant emission rate level (Fc0) of Japanese Agricultural Standards (JAS Standards). The guidelines were implemented in October 1999.

1-3 Revision of the specifications for public housing construction

Construction specifications for public housing written by the MLIT, which carefully take into consideration the health of the occupants, were re-examined. The MLIT revised the specifications by adding a provision concerning the building materials that are used for finishing the interior, stating that materials must be used which are ranked as Fc0 level in JAS (the minimum level of formaldehyde emission rate), which ensures a low emission rate of pollutants. The related industries were notified of this revision in April 1999.

1-4 Introduction of incentive loans for the construction of private houses

The MLIT adopted a policy for the support of applicants for housing loans. These loans are sponsored by the "Government Housing Loan Corporation". The applicants can borrow an additional ¥2 million (approx. US \$20,000) if the desired house is equipped with ventilation systems designed for energy efficiency and health aspects. Moreover, applicants can borrow an additional ¥4 million (approx. US \$40,000) when the

houses for which a loan is applied have energy and health considerations built into them (high performance houses).

1-5 Establishment of the Housing Performance Indication System

On 23 June 1999, the MLIT established the “Housing Quality Assurance Act,” for indicating the performance of housing. This law aims to assure various housing performances, e.g. performance of structure, performance of fire protection, performance of IAQ, performance of energy consumption etc. In this law, formaldehyde emissions (from interior finishing materials used for living rooms, bedrooms, etc. and from finishing materials used for closets and furniture built into these rooms) are evaluated and indicated based on formaldehyde emission grading methods, specified in the Japanese Industrial Standards (JIS) and the Japanese Agricultural Standards (JAS). Thus, this law evaluates the grade of the building materials, such as plywood and particle board, according to the emission levels of formaldehyde, in order to predict the IAQ (Indoor Air Quality) within the constructed houses. The law took effect in 2000.

1-6 Organising the committee for the “Research on IAQ Improvement”

In June 2000, the MLIT established a new body “Research Committee on IAQ Improvement,” a successor to the previous committee, the “Healthy House Research Committee.” This committee is now discussing improvements to the guidelines established by the previous committee.

1-7 Rental Service of simple instruments for measuring chemical compounds

The “Organisation for Housing Warranty” started a rental service system of simple instruments for measuring chemical compounds. Housing occupants can use this rental system for measuring chemicals independently.

2. Policies adopted by and actions taken by the MHLW

The MHLW (Ministry of Health, Labour and Welfare), which is responsible for public health and welfare, began taking various measures towards the sick house problem at the earliest stage.

2-1 Major research projects

- Research on the management standards for IAQ and indoor climate in commercial buildings

This research began in 1988 as a joint project involving IPH (Institute of Public Health which belongs to the MHLW), WFBS (World Federation of Building Service Contractors) and WHO (World Health Organisation). One of the research objectives was to compare various indoor environments in Japanese commercial buildings, which are regulated by the "Law for Maintenance of Sanitation in Buildings", to those in other countries where no such law exists, by measuring the indoor environments of each country based on methodologies defined by the Law.

In this project, WHO required the measurement of the indoor VOC (Volatile Organic Compound) concentrations in Japanese commercial buildings, since WHO felt that there was a lack of VOC data in Japan at that time. VOCs are believed to be a major cause of sick building syndrome, which is a very

serious social problem in European and American countries. The VOC measurements in response to the WHO proposal were carried out in 10 commercial buildings in Tokyo, which were regulated by the Law. It became clear that formaldehyde concentrations were not high compared with the so-called "WHO guideline" of 0.08 ppm (100 $\mu\text{g}/\text{m}^3$). TVOC (Total VOC) concentrations were, on the other hand, extremely high compared with the so-called "WHO guidelines," 300 $\mu\text{g}/\text{m}^3$. The TVOC concentrations in all ten buildings exceeded the guidelines and some reached values as high as one order higher than the guidelines.

Considering the measurement results in commercial buildings, high concentrations of TVOC within residential buildings can also be expected, since the construction methods and finishing materials used in residential buildings are similar to those used in commercial buildings.

- Research on VOCs emitted from building materials and furnishings

This project started in 1995, in response to the results of the previous joint project between IPH, WFBSC, and WHO.

Measurement results were obtained for 20 newly constructed detached houses and for 10 existing houses in cities located in the northern part of Japan. The results showed that formaldehyde concentrations of 3 to 4 of the 20 new houses exceeded 0.08 ppm, while TVOC concentration of all the houses far exceeded the 300 $\mu\text{g}/\text{m}^3$ limit. Some reached nearly 5,000 $\mu\text{g}/\text{m}^3$.

- Nationwide survey on indoor formaldehyde concentrations in Japanese houses

The MHLW and NIHS (National Institute of Hygienic Science) conducted this project from 1996 to 1999 in co-operation with the nationwide hygienic research institutes of prefectural Governments. Results of formaldehyde concentrations obtained from 79 newly constructed and 150 existing houses showed that the measured values of about 28% of the surveyed houses exceeded 0.08 ppm.

- Nationwide survey on indoor VOC concentrations in Japanese houses

This survey was carried out in 1997 by the same organisation mentioned above as a successor to the previous survey. Results showed that indoor concentrations of 40 kinds of VOCs, including para dichlorobenzene, in the 230 houses were generally higher than those of outdoors. The average concentration of toluene was 98 $\mu\text{g}/\text{m}^3$ and 6% of the measured values in the surveyed houses exceeded the "WHO guidelines," 260 $\mu\text{g}/\text{m}^3$ with some reaching as high as 3400 $\mu\text{g}/\text{m}^3$. The average concentration of TVOC for newly constructed houses was 300 $\mu\text{g}/\text{m}^3$ and much higher than concentrations in existing houses.

- Research into MCS (Multiple Chemical Sensitivity)

This research was carried out in 1996 by a research group sponsored by the MHLW as a part of allergy research. They made a pamphlet on MCS that is widely used as an educational guidebook for this problem.

2-2 Establishment of guidelines

- Formaldehyde

In 1996, the MHLW established a guideline for indoor formaldehyde concentrations in housing based on the discussions of the committee, to realize healthier and more comfortable houses. The guideline

generally followed WHO guidelines and stated that indoor levels should be less than 0.08 ppm (100 $\mu\text{g}/\text{m}^3$) for an average period of 30 minutes. This was the first guideline in Japan which controls chemical compounds used in housing. The indoor formaldehyde levels in newly constructed Japanese houses decreased dramatically after the establishment of this guideline.

- Toluene, xylem and para dichlorobenzene

In June 2000, the MHLW issued guidelines for other chemical compounds, following the one for formaldehyde. Guideline values are shown in Table 2.

Table 2 Guidelines for VOCs

NAME OF VOCS	Guideline value	Background to the guideline
Toluene	0.07 ppm 260 $\mu\text{g}/\text{m}^3$	<ul style="list-style-type: none"> ▪ Effects on human nerve function ▪ Effects on human reproductive ontogeny
Xylem	0.2 ppm 870 $\mu\text{g}/\text{m}^3$	<ul style="list-style-type: none"> ▪ Effects on growth of infant rats ▪ Effects on human central nervous system
Para dichlorobenzene	0.04 ppm 240 $\mu\text{g}/\text{m}^3$	<ul style="list-style-type: none"> ▪ Effects on liver and kidney functions of a beagle dog

- Ethyl benzene, styrene, chlorpyriphos, di-n-butyl phthalic acid and TVOC

In September 2000, the MHLW issued guidelines for those chemicals shown below, in succession to the guidelines for the four chemical compounds already issued.

The most outstanding feature of this guideline is that the TVOC value of 400 $\mu\text{g}/\text{m}^3$ has been announced, even though the value is tentative at present. This is a challenging trial by the MHLW. The MHLW established its guideline values based on the evidences shown here and not based only on medical data, because it was difficult to gather sufficient medical evidence at that stage.

Table 3 Guidelines for VOCs (continued)

VOCs	Guideline value	Background to the guideline
Ethyl benzene	0.88 ppm 3800 µg/m ³	<ul style="list-style-type: none"> ▪ Effects on liver and kidney function of rats and mice
Styrene	0.05 ppm 225 µg/m ³	<ul style="list-style-type: none"> ▪ LOAEL for brain and liver of rats
Chlorpyrifos	0.07 ppm (adult) 1 µg/m ³ 0.007 ppm (child) 0.1 µg/m ³	<ul style="list-style-type: none"> ▪ Effects on brain development of new-born or infant rats
Di-n-butyl phthalic acid	0.02 ppm 20 µg/m ³	<ul style="list-style-type: none"> ▪ LOAEL for sexual organs of rats
TVOC	400 µg/m ³	Practically achievable level judged by results of nationwide survey. Not based on medical evidences. The value is tentative.

2-3 Consolidation of consulting systems

The MHLW is taking measures to consolidate the consulting systems of regional health centres and hygienic research institutes of each prefectural Government. Consulting systems, including that for VOC measurements, have been established in some larger prefectural Governments, such as the Tokyo Metropolitan Government, and the Municipality of Yokohama City.

2-4 Construction of a specialised hospital for MCS

The MHLW is constructing a specialised hospital for MCS, which is equipped with special chemical-free clean rooms for medical check-ups.

3. Policies adopted and action taken by the METI

The METI (Ministry of Economy, Trade and Industry) is also working in various ways toward solving the sick house problem, following the MLIT and the MHLW. The METI is responsible for establishing countermeasures concerning furniture and equipment, while the MLIT is in charge of the establishment of countermeasures for buildings.

3-1 Establishment of Japanese Industrial Standards

The METI has already issued Japanese Industrial Standards (JIS) for measuring method of formaldehyde emission levels from particle board and fiberboard, wallpaper, adhesives, and other chemical products as well as the evaluation method for such products. It has also started a program to establish new JIS codes for formaldehyde and for VOC measurements.

3-2 Encouragement of Technical Development

The METI is now encouraging Japanese industries to undertake research in order to develop low formaldehyde emission adhesives and materials for furnishings and buildings, called "healthy materials."

4. Measures taken by FA

The FA (Forestry Agency) is one of the most important agencies along with the MLIT, the MHLW and the METI for developing countermeasures to the sick house problem. This agency is responsible for establishing countermeasures for plywood.

4-1 Establishment of Japanese Agricultural Standards

The FA has recently revised the Japanese Agricultural Standards (JAS) for formaldehyde emission levels from plywood (from F1, F2, F3 to Fc0, Fc1, Fc2). FA is also encouraging manufacturers to develop low formaldehyde emission plywood.

5. Measures taken by MEXT

The MEXT (Ministry of Education, Culture, Sports, Science and Technology) has financially supported a committee, which was set up in the Architectural Institute Japan to research chemical pollution within rooms and encourages research for the accomplishment of healthy housing and healthy buildings.

The MEXT has begun to do research on IAQ in schools in response to the recent public concern to IAQ problems in schools, which are known as "sick schools" in Japan

6. Summary of policies and actions by the Japanese Government

The MLIT (Ministry of Land, Infrastructure and Transport) has established construction guidelines for buildings and finishing materials in response to the MHLW's IAQ guidelines.

The MHLW (Ministry of Health, Labour and Welfare) established IAQ guidelines for various chemical compounds, including TVOC, based on health effects and other considerations.

The METI (Ministry of Economy, Trade and Industry), which has issued industrial codes called "JIS codes," is encouraging Japanese industries to develop low formaldehyde emission materials, so called "healthy materials."

The FA (Forestry Agency) has recently revised the Japanese Agricultural Standards (JAS) for formaldehyde emission levels from plywood. The FA is also encouraging companies to develop low formaldehyde emission plywood.

The MEXT (Ministry of Education, Culture, Sports, Science and Technology) supported the research committee organised in the Architectural Institute of Japan. The MEXT has also begun to do research on IAQ in schools.

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